ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

VOL. XL. No. 5.

TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 65
The New East River Bridge, New York City (illustrated) 66
The Machinery of the New Torpedo-Boats and Torpedo-Boat Destroyers 66
The "Boot-Jack" Signals of the Lake Shore & Michigan Southern Ry. (illustrated)..... 66
The Fairmount Park Arch Bridge (with two-page plate)..... 67
Water Power Development by the Lake Superior Power Co. at St. Mary's Falls, Mich. (illustrated). 68
The Walker Conduit Electric Street Railway System (illustrated)..... 71
Massachusetts Experiments on the Purification of Fresh, Stale and Septic Sewage 75
A Comparison of British and American Naval Vessels 77
New Styles of Reducing Valves (illustrated)..... 78
Electric Welding of Street Railway Rails (illustrated) 78
Annual Convention of the American Society of Civil Engineers. 80
EDITORIAL NOTES 72
New Designs to be Made for the New Battleships—The Accuracy of Modern Bridge Shop Work—The Province of the Bacteriologist in Connection with Public Water Supplies.
EDITORIAL:
The Position of United States Assistant Engineers.. 72
LETTERS TO THE EDITOR 74
The Paints on the 155th St. Viaduct, New York city—A Problem in Solid Geometry (illustrated)—The Modull of Elasticity of Cast Iron—Power of Windmills.

THE PROPOSED STORAGE DAM AND RESERVOIR for the water-works system of Columbus, O., has been reported on by Mr. Jas. D. Schuyler, M. Am. Soc. C. E., of Los Angeles, Cal., who spent some time in Columbus for that purpose. Mr. Schuyler approves the general plan proposed by Mr. Julian Griggs, Chief Engineer of Public Improvements of Columbus, but recommends that the concrete dam be 52 instead of 30 ft. high, and that instead of an overflow dam a spillway be provided. A dam 52 ft. high would impound 5,681,000,000 gallons of water and flood nearly 500 acres, forming a long, narrow reservoir, very favorable to sedimentation. Mr. Schuyler also recommends that the curvature of the dam be increased by diminishing the radius from 1,910 to 800 ft., or less.

THE LITIGATION OVER UNDERGROUND WATER supply, brought by Walter R. Smith against the former city of Brooklyn, N. Y., has again been decided in favor of the plaintiff. The plaintiff alleged that an artificial pond, from which he obtained ice, had been dried up by the driven wells sunk by the city a few years ago. The facts in the case, together with its course in the courts were given in an editorial on "Riparian Rights in Underground Waters," in our issue of Aug. 19, 1897. The present decision was made by the Appellate Division of the Supreme Court of the State of New York, and affirms an award of $1,800 damages to Mr. Smith, made in a jury trial.

THE SECOND TRIAL OF THE SUIT of Joseph H. Smith et al vs. Salt Lake City, Utah, has been completed, and the decision of the referee was rendered July 14. This was a suit brought by the bondsmen of Dubois & Williams, the original contractors for the Parley's canyon conduit for supplying Salt Lake City with water. (See Engineering News, Oct. 22, 1896.) The bondsmen completed the work at a loss, and soon thereafter filed an action against the city to recover $97,000. They alleged in their complaint that the city changed the route of the conduit after the original contract was entered into, thus requiring the use of much more material than would otherwise have been needed. The trial was had before the same referee as in June, 1893, and the city won on every point. As that was in territorial days, the case came up before Judge Hallett of the Federal Court at Denver, who last winter granted a new trial, being of the opinion that it was to be assumed that a route had been established before the contractors bid upon the work, and if so that the contractors were entitled to extra pay. The case has been very strongly contested by the city, and at the second trial a number of the leading engineers and contractors of the state were employed, who inspected the completed work very thoroughly and who showed that the contractors did not lose the large amount of money claimed, and that one route would have been as expensive as the other. However, by the late decision, the referee awarded the plaintiffs $10,044, together with interest at 8%, from Feb. 4, 1892 (the date of the completion of the work), making a total of $15,245, and also the costs of the several hearings, about $3,000 more. The referee's report will have to again go to Judge Hallett, and it is likely that a bitter contest over its confirmation will be made, as neither side is satisfied with it.

THE EFFECTIVENESS OF AUTOMATIC SPRINKLERS was well shown in a recent fire in a storehouse at the Atlantic White Lead Works in Brooklyn. Only a portion of the building was protected by sprinklers. The fire originated on the second floor, about 30 ft. from the protected portion, and extended through all of the unprotected part of both the second and third floors, but was completely checked at the point where the sprinklers were located, the stock, plumber's materials packed in hay, being wet thoroughly. The loss would have been insignificant if the whole building had been protected.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Aug. 1 on the Central of Georgia Ry., at Fort McPherson, Ga., in which a train carrying troops for the Camp at Lithia Springs was run into by a freight train. No soldiers were hurt, but two railway employees were killed and three injured.

EXCESSIVE EXPANSION OF THE BROOKLYN Bridge by the extreme heat of July 29, coupled with a blockade of trolley cars covering practically the entire suspended span, resulted in a slight buckling of the bottom chords of four of the six stiffening trusses. The damage done was unimportant in itself, and is chiefly interesting for the lessons which it teaches respecting certain features of the construction and the need of a more rigid regulation of the electric railway traffic. In our next issue we hope to give fuller details of the accident.

THE REPORT ON THE "BOURGOGNE" DISASTER, made by the Court of Inquiry held at Halifax, N. S., exonerates the Captain and crew of the sailing vessel "Cromartyshire" from all blame for the collision. Concerning the course on which the French steamer was sailing at the time of the collision, Capt. W. H. Smith, of the Royal Naval Reserve, who was the Government's special commissioner in the investigation, said:

It appears to me that "La Bourgogne," as a mail steamship starting from New York, was not in the position at the time of the collision as indicated by the steam lanes upon the pilot chart of the North Atlantic, where the steamship routes are laid down, and in the note upon the chart it is stated: "The principal transatlantic steamship companies have adopted these routes, and sailing vessels are requested to avoid them as much as possible."

It also appears to me that it is highly desirable that the rule of following the steam lanes should be made binding on all steamships navigating the Atlantic, when plying between New York and European ports.

"It is of much importance to all concerned that steamers carrying a large number of passengers between New York and European ports should, if practicable, traverse the Atlantic upon such safe courses that in all probability would take them clear of the most dangerous locality, and, if possible, steamers should especially avoid that portion where fogs are frequently known to exist and may be encountered at any time, more particularly during the summer months under certain conditions of weather and direction of wind.

"I am of the opinion that it is desirable that new lane routes should be selected for fast passenger steamers to and from American ports. These routes should be established by law and adopted by the governments of the various localities.

"The route I propose is as follows: Leaving New York, a course direct from Sandy Hook to longitude 70° west, in latitude 40° north, and follow that parallel of latitude until longitude 47° west is reached, then each ship could pursue the great circle course, either to Fastnet Rock Lighthouse, coast of Ireland, or the Scilly Islands, as the case might be. On the westerly or outward passage, steamers should go 30 miles to the northward of this route. Upon such a route, probably, no fog or icebergs would be encountered, and only an occasional derelict, which could be seen by a good lookout."

FIREPROOF WOOD IN THE NEW WARSHIPS is advocated by Chief Naval Constructor Hichborn; but is opposed by the other three members of the Naval Construction Board, and the matter is referred to Secretary Long for final decision. The burning of the Spanish ships at Santiago has called renewed attention to the danger resulting from combustibles on board war vessels. On the other hand the fireproofing chemicals used in treating the wood are said to cause corrosion wherever it comes in contact with iron, and if the wood is exposed to moisture the chemicals may become leached out and the wood may lose its fireproof character. A later report states that the Secretary has approved Constructor Hichborn's report, and that all wood used in the new vessels will be fireproofed.

A BURGLAR-PROOF VAULT OF ARMOR PLATE is being constructed by the Carnegie Steel Co. for the Union Trust Co., of Pittsburg. The interior of the safe, or vault, is to be 18½ × 16½ ft. by 9½ ft. high. Eleven plates of face-hardened, reforged nickel steel armor plate are to be used, aggregating 396,750 lbs. The size and location of these plates are described as follows: The front plate will measure 234 × 114 × 8 ins., and will weight 46,150 lbs. It will be reinforced by a rolled steel plate 222 × 102 × 6¼ ins., weighing 38,200 lbs. The door will be circular, 87 ins. diameter, 8½ ins. thick, and will weigh 15,400 lbs. It will also be reinforced, but with a cast-steel plate, 86 ins. diameter, 3 ins. thick in the center and 6 ins. thick on the edges, weighing 7,500 lbs. The back plate will be 234 × 114 × 6 ins., 45,000 lbs., two side plates, 208 × 110 × 6 ins., 39,000 lbs. each; two top plates, 226¼ × 106 × 6 ins., 41,000 lbs. each; two bottom plates, 234 × 106 × 6 ins., 42,250 lbs. each. The vault is to be constructed under the Hollar-Kennedy patent. No bolts are to be used, the plates being dovetailed together. The flanges of the plates are wedged snugly in undercut grooves of corresponding shape cut in the connecting plates, thus preventing movement in any direction. The vault will have a foundation of heavy masonry. The door will be ground to an air and gas-tight joint and will be secured by 27 heavy radial bolts. The mechanism for actuating the bolts will be checked by three time locks.

A STAND OF COLORS, costing approximately $500, will be presented by The Engineers' Club of New York city to the first of the three regiments of Volunteer Engineers, authorized by Congress and now in camp at Peekskill, N. Y. It is also proposed to purchase a searchlight outfit for the first regiment, and The Engineers' Club has undertaken the work of raising the amount necessary, about $3,000. Subscriptions should be sent to Mr. S. W. Baldwin, Treasurer, care of The Engineers' Club, 374 Fifth Ave., New York city.

EXPORTS OF MANUFACTURED GOODS from the United States for the fiscal year ending June 30 were the largest ever recorded, amounting to $288,871,449, or nearly 12 million dollars more than in any preceding year, more than double the exports of such goods a decade ago, and almost three times as much as in 1880. It is interesting to note that exports of bicycles amounted to $6,846,520, against less than two million dollars in the preceding year. The Bureau of Statistics of the Treasury Department has issued an interesting summary, showing the exports of the principal lines of manufactured goods in the last fiscal year and in the year ending June 30, 1888. We reprint it as follows, and would call especial attention to the growth in the exports of manufactures of iron, steel and copper.

Articles exported.	Year ending June 30, 1898. Value	1888. Value
Starch	$1,850,353	$202,932
Flax, hemp and jute manufactures..	2,557,465	1,391,216
Instruments for scientific purposes..	2,770,803	714,514
Cars, carriages, etc.	3,424,419	2,243,756
Fertilizers	4,359,834	1,255,028
Tobacco, manufactures of	4,818,493	3,578,457
Paper, and manufactures of	5,494,564	1,078,561
Paraffine and paraffine wax	6,030,292	2,163,242
Cycles, and parts of	6,846,520	.....
Agricultural implements	7,090,732	2,645,187
Chemicals, drugs, dyes & medicines.	9,441,762	5,622,972
Cotton, manufactures of	17,024,092	13,019,180
Leather, and manufactures of	21,112,640	9,583,411
Copper, and manufactures of	32,180,872	3,812,768
Mineral oil, refined	51,782,316	47,042,400
Iron and steel, manufactures of....	70,367,527	17,763,034

In view of the interest just now felt in our trade with the Orient, it may be remarked that Japan bought 53 million gallons of our mineral oils and China 44 million gallons.

AMERICAN INTEREST IN THE PARIS EXHIBITION of 1900, it is hoped, will now be stimulated by the appointment of Mr. Ferdinand W. Peck as Commissioner-General for the United States. Mr. Peck was chairman of the Finance Committee of the Chicago exhibition, and was a member of the preliminary commission which was sent to Paris over a year ago. The business manager on Mr. Peck's staff will be Mr. Paul Blackman, who was Chief of Concessions of the Chicago exhibition. A permanent office of the Commission will shortly be opened in New York city, and several departments will be created, including those of agriculture, transportation, electricity, fine arts, machinery, American inventions, and mines and mining. The head of the last named department will be Mr. J. F. V. Skiff, who was the chief of the similar department in the Chicago exhibition.

THE PNEUMATIC MAIL TUBE SYSTEM connecting the Brooklyn and New York General Post Offices was opened Aug. 1 before about 200 persons. The first carrier made the round trip from Brooklyn and back in six minutes and two seconds. The cost of the plant was about $60,000, and the government is to pay a rental of $14,000 per year to the New York Newspaper and Transportation Co. for carrying first-class matter.

LIGNITE is being used for fuel by the Houston & Texas Central Ry. For switching engines it is used alone, with improved draft appliances and the diamond stack, but for road engines it is mixed with equal parts of coal. The results of the use of lignite are given by Mr. S. R. Tuggle, Superintendent of motive power of the road, in a paper read before the Texas Railway Club. He says that besides the saving in cost, due to the shorter haul, large beds of the lignite being near the main line of the road, there has been a saving in repairs of flues, stay-bolts and fire-boxes.

THE NEW EAST RIVER BRIDGE, NEW YORK CITY.

We show herewith a perspective view of the New East River Bridge, now under construction between New York and Brooklyn, which we have had engraved from a water-color drawing made for the New East River Bridge Commission by Mr. C. W. Reinhardt, Chief Draftsman of Engineering News. Details of the tower foundations, anchorages, end spans and towers proper of this bridge were published in our issues of May 27 and Sept. 9, 1897, and Feb. 17, 1898, and only a few of the leading dimensions of the completed structure will be given here. These are as follows:

	Feet.
Length between terminals	7,200
Width, out to out	118
Minimum height at pier-head lines	117
Minimum height at center of span	135
Height of masonry in tower foundations above mean high water	20
Height of center of cables at top of towers above mean high water	335
Width of carriageways, each	18
Width of two footwalks, each	12
Width of four trolley-car tracks, c. to c.	10
Width of two elevated railway tracks, c. to c.	12
Distance apart of stiffening trusses, c. to c.	72

The towers above the masonry and the entire suspended structure, except the flooring, will be of steel. The four suspension cables will each be 17½ ins. in diameter.

As most of our readers will remember, Mr. L. L. Buck, M. Am. Soc. C. E., is Engineer in Chief of the new bridge, and Mr. O. F. Nichols, M. Am. Soc. C. E., is his principal assistant. Work is now in progress upon the tower foundations and the anchorages, and bids have been received for constructing the towers and end spans, but contracts have not been awarded.

PERSPECTIVE VIEW OF THE NEW EAST RIVER BRIDGE BETWEEN NEW YORK AND BROOKLYN.
L. L. Buck, M. Am. Soc. C. E., Chief Engineer.

THE MACHINERY OF THE NEW TORPEDO BOATS AND TORPEDO-BOAT DESTROYERS.

The machinery of the 12 new torpedo boats and 16 torpedo-boat destroyers is described as follows in the official circular to bidders, issued by the Navy Department. The bids for these vessels are to be opened on Aug. 23:

Torpedo Boat.

The propelling engines will be of the vertical four-cylinder, direct-acting, triple-expansion type, each with cylinders 14, 22 and 25¼ ins. diameter and 18 ins. stroke. The indicated horse-power of the propelling engines will be about 3,000 when the engines are making about 350 revs. per min. The propelling engines will be placed in separate water-tight compartments, with the high pressure cylinders forward and the low pressure cylinders aft.

The main engines will be balanced in an approved manner. The main valves will be piston valves, one for each h-p. cylinder, operated by the Stephenson link motion. Each main piston will have one piston rod, with a crosshead working in a slipper guide.

The framing of the engines will consist of vertical forged-steel columns, stayed by forged and cast-steel ties and braces. The engine bedplates will be of cast steel, supported on forged steel keelson plates built in the vessel.

The crank shafts will be made in one section and will be hollow. The shafts, piston rods, connecting rods, valve rods, eccentric rods, and working parts generally, will be forged of nickel steel.

There will be two condensers made entirely of composition and sheet brass. Each will have a cooling surface of about 1,240 sq. ft., measured on the outside of the tubes, the water passing through the tubes. For each main engine there will be one double-acting air pump, driven from the main engine shaft. The circulating pumps will be of the centrifugal type, one for each condenser.

The propellers will be right and left, of manganese bronze or approved equivalent metal.

There will be three water-tube boilers constructed for a working pressure of 250 lbs. per sq. in. Two of these boilers will be placed in a water-tight compartment forward of the engines and the other one will be placed in a water-tight compartment abaft the engines. The total grate surface will be at least 137 sq. ft. and the total heating surface at least 7,544 sq. ft. There will be three smoke pipes, one for each boiler.

There will be two main feed pumps, one in the forward fire room and the other in the after engine room. These pumps will each have a capacity of 147 gallons per minute at a piston speed of 100 ft. per minute. There will be one auxiliary feed pump, located in the forward engine room. The capacity of this pump will be 147 gallons per minute at a speed of 100 ft. per minute. There will be one fire and bilge pump in the after engine room, having a capacity of 147 gallons per minute at a speed of 100 ft. per minute.

There will be two blowers in the forward and one in the after fire room. There will two evaporators and one distiller, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the detailed specifications or shown in the drawings.

The weight of all the machinery and boilers, including auxiliaries and radiators and water in the boilers, condensers and pipes, and such stores and spare parts as may be carried on board when fully equipped must not exceed 79.745 tons.

Torpedo-Boat Destroyers.

The propelling engines will be alike, and each will be placed in a separate water-tight compartment. These engines will be of the vertical four-cylinder, direct-acting, triple-expansion type, each with cylinders 20½, 32 and 38 ins. diameter and 22 ins. stroke. The indicated horse-power of propelling engines will be about 8,000 when the engines are making 327 revs. per min., the steam pressure at the engines being 250 lbs. per sq. in. above atmosphere. The order of cylinders will be as follows, beginning forward: For the starboard engine, second low-pressure, intermediate, high and first low-pressure; for the port engine, first low-pressure, high, intermediate, second low-pressure. The cranks will be at 90°, the high and first low-pressure cranks being opposite, as also the intermediate and second low-pressure, the second pair being at right angles with the first pair. The weights of the pistons will be such as to make the weights of reciprocating parts the same for all cylinders, the weights of the air-pump pistons and moving parts actuating them being taken into consideration. Any other system of balancing, which the contractors may wish to use, will be considered by the Bureau of Steam Engineering. The balancing of rotating weights of main engines by counterweights on the crank webs is left optional with contractors.

The main valves will be worked by means of Stephenson double-bar links. All the main valves will be piston valves, double-ported for steam, there being one for each high-pressure, two for each intermediate-pressure, and two for each low-pressure cylinder.

Each main piston will have one piston rod, with a crosshead working in a slipper guide. The framing of the engines will consist of vertical forged-steel columns, well stayed by diagonal braces. The engine bedplates will consist of a separate steel casting for each bearing, all supported upon and bolted to two fore-and-aft plates, which latter are supported by and form part of the engine keelsons, carefully and strongly worked into the framing of the vessel. The crank shafts will be made in two sections and will be hollow.

The shafts, piston rods, connecting rods and working parts generally, will be forged of high-grade steel.

There will be two condensers, made entirely of composition and sheet brass. Each will have a cooling surface of about 3,470 sq. ft., measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be two double-acting vertical air pumps driven from the high and intermediate pressure crossheads. The circulating pumps will be of the centrifugal type, one for each condenser. The propellers will be right and left, of manganese bronze or approved equivalent metal.

There will be four water tube boilers, constructed for a working pressure of 300 lbs. per sq. in. Two of these boilers will be placed in a water-tight compartment forward of the engines, and the others will be placed in a water-tight compartment aft of the engines. The boilers in the after boiler compartment and the after boiler in the forward compartment will be alike, each containing about 80.5 sq. ft. of grate surface; the forward boiler will not be as wide as the others, and will contain about 73.5 sq. ft. of grate surface, the length of grates not exceeding 7 ft. in all the boilers. The total grate surface will be at least 315 sq. ft. and the total heating surface at least 17,768 sq. ft. There will be four smoke pipes, one for each boiler.

There will be four main feed pumps, each of a rated capacity of about 150 gallons per minute. They will be located, one in each engine room, and one in each fire room. All these pumps will draw from the feed tanks and from the reserve water tanks, as specified elsewhere, and will deliver into the main feed pipe. The main feed pumps located in engine rooms will deliver into both the main and the auxiliary feed systems. The main feed pump in the after engine room will draw from the reserve water tanks through a separate pipe. Both main feed pumps in engine rooms will draw from the air-pump channel ways.

There will be two auxiliary feed pumps, one in each fire room, of the same capacity as the main feed pumps. They will draw from the feed tanks, the reserve water tanks, and the sea, and discharge into the auxiliary feed pipe, into the fire main, and the ash ejectors. There will be in each engine room a fire and bilge pump. These pumps will draw from the bilge, through the auxiliary drain, and from the sea, and deliver overboard and in the fire main. There will be two blowers in each fire room.

The water level in each boiler will be controlled by an approved feed regulator.

There will be two evaporators and one distiller, and other auxiliary or supplementary machinery, tools, instruments, or apparatus as described in the detailed specifications.

The weight of all the machinery and boilers, including auxiliaries and heaters and water in the boilers, condensers, pipes, and feed tanks, and such stores and spare parts as may be carried on board when fully equipped will not exceed 190 tons.

THE "BOOTJACK" SIGNALS OF THE LAKE SHORE AND MICHIGAN SOUTHERN RY.

In the early use of railway signals and signaling little or no attempt was made at uniformity, and each road used such forms of targets, arms, etc., as it deemed best. As the art of signaling has improved and its use has become more general, however, the advantages incident to uniformity in signals and rules have become more generally recognized, and at the present day the semaphore form of signal is almost universally considered as the standard form, although the use of disks is still continued in certain automatic signals. Even in England a few examples of obsolete forms of signals are still to be seen; and in this country, where the introduction of signaling on a large scale is of comparatively recent date, there are still in use a number of special and peculiar signals which have been introduced by individual roads and are still continued in service.

An example of these is the "bootjack" signal, which is a feature of the Lake Shore & Michigan Southern Ry., and the general form of which is shown in Fig. 1. The signal has two arms at right angles to one another, both arms being in one piece, which is pivoted at the heel, a small counterweight at the heel balancing the arms and facilitating the working of the signal, besides returning it always to the "danger" position should the operating mechanism be broken. On the spindle of the signal is keyed a cogwheel, whose teeth engage with a rack on a vertical rod, to the lower end of which is attached a lamp. This lamp slides up and down in a box fitted with four or six lenses on one or both sides, according as the signal has four or six positions, and governs train movement in one or both directions. For six-position signals, two lamps are usually employed, placed side by side and moved together, showing two lights for each position of the arm. The signal is the invention of Mr. Wm. Gravit, Master Carpenter of the Lake Shore & Michigan Southern Ry., and has been in use since about 1881. It is used entirely on the main line, and to some extent on the branches, for block or train-order signaling, and is also used at junctions and for governing switch movements.

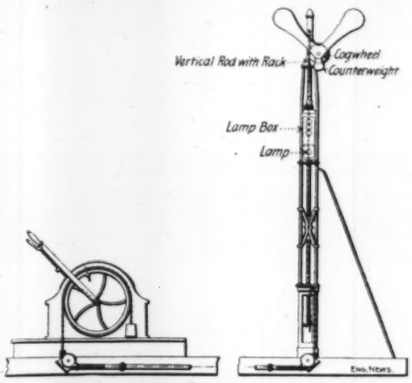


Fig. 1.—Bootjack Signal on the Lake Shore & Michigan Southern Ry. (Danger Position.)

In governing the movement of trains the signal has four positions: (1) Both arms pointing upward in V shape, both tracks blocked; (2) one arm horizontal and pointing south (and the other hanging down), south track blocked; (3) one arm horizontal and pointing north (and the other hanging down), north track blocked; (4) both arms pointing downward like an inverted V, both tracks clear. For these indications only two colors are used, white and red. At crossings and junctions, however, two additional positions are used, with the arm forming a horizontal V on one or other side of the post. For these signals there are six lenses, one above the other, but in most of the six-position signals there are two lamps placed side by side and moving together, showing two lights of the same or different colors for each position of the arm. For these signals white, red, and green lenses are used. The arms are invariably painted red on both sides.

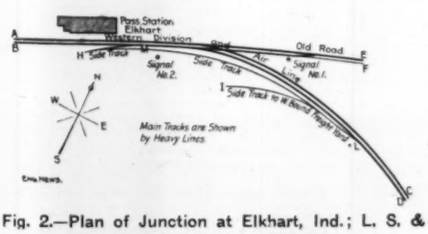


Fig. 2.—Plan of Junction at Elkhart, Ind.; L. S. & M. S. Ry. (Showing Signals).

The arrangement and indications of the signal will be clearly understood from Figs. 2 to 5. In Fig. 2 is shown a plan of the junction of the single track Old Road, with the double track Air Line and Western Division at Elkhart, Ind. The junction of these three divisions is opposite the station building, and train movements are governed by two "bootjack" signals and a single-arm block signal at the west end of the yard, 2,300 ft. west of the station. The sidetrack, I, leads from the Air Line into the westbound freight yard. The sidetrack, H, connects with both the Air Line and the Old Road. Eastbound freight is passed from H to to the Air Line either at M or around the sidetrack to L. Signal No. 1 is for switching movements only, and is a six-position double-lamp signal. Signal No. 2 refers to eastbound trains only, and its two lamps show in one direction only. The positions and lights of these two signals for their several indications are shown in Fig. 3. Westbound trains are controlled by the single-arm signal above mentioned, passenger trains from the station to this signal being given clearance cards through the yard.

Fig. 4 is a plan of the junction of the Jackson Branch and Monroe Branch with the main line of the Old Road at Lenawee Junction, Mich. Two signals are used, one of which is a "bootjack" with a single lamp showing a light in each direction, and the other is a pivoted red arm or target with two red lamps suspended from it. The positions and indications of these two signals are shown in Fig. 5.

These signals appear to be somewhat complicated and confusing in their indications, although we are informed that no complaints in these respects have been made by the operating department. Nevertheless the use of odd and peculiar signals is not to be recommended in these days, the advantages of uniformity having been so well established, nor is it good practice to attempt to make one signal give so many indications. When some more modern system of block signaling is introduced on the Lake Shore & Michigan Southern Ry. it is to be hoped that it will conform to the accepted standards, for reasons which have been editorially discussed in our issues of Jan. 20 and May 12.

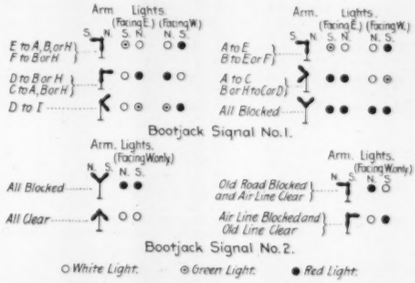

Arm. Lights. (Facing E.) (Facing W.)
N. S. N. S.
E to A, B, or H / F to B or H
D to B or H / C to A, B or H
D to I
A to E / B to E or F
A to C / B or H to C or D
All Blocked
Bootjack Signal No. 1.
Arm. Lights. (Facing W only)
All Blocked
All Clear
Old Road Blocked and Air Line Clear
Air Line Blocked and Old Line Clear
Bootjack Signal No. 2.
White Light. Green Light. Red Light.

Fig. 3.—Positions and Colors of Four-Position and Six-Position Bootjack Signals at Elkhart.

It may be noted that on this road there is no signal engineer in charge of either the interlocking plants or the block or train-order signals, the latter being under the telegraph and operating departments. This anomalous condition of affairs is not by any means confined to the L. S. & M. S. Ry., however, as shown in a paper by Mr. W. H. Elliott, in our issue of Jan. 20; but in view of the rapid growth of signaling and block working on important lines it is most desirable that all work of this kind should be concentrated under the charge and supervision of one head in one department.

THE FAIRMOUNT PARK ARCH BRIDGE, PHILADELPHIA.

(With two-page plate.)

In our issue of July 2, 1896, we published the accepted design made by the Phoenix Bridge Co., for the new bridge to be built by the Fairmount Park Transportation Co., over the Schuylkill River, Fairmount Park, Philadelpia. This structure is now completed and in service, and on our double-page plate this week we present some of the more important metal work details and other interesting structural features of the work. It may be recalled to mind in this connection, also, that shortly after the design for this bridge was accepted there arose some discussion as to its fitness, which was given quite fully in Engineering News of Aug. 13, 1896. A study of the details shown here is made of somewhat more interest by reading this discussion in the same connection.

The general design of the Fairmount Park bridge is shown by Fig. 1. It consists of four 208 ft. stiff braced arches flanked on one end by two 70-ft. and one 85-ft. lattice spans, and at the other end by two 70-ft. and one 40-ft. spans. The total length of the bridge, excluding the embankment approaches, is thus 1,097 ft. Two electric railway tracks, a carriage-way and a foot-walk cross the bridge, the total width of 79 ft. 3 ins. being divided between them, as shown by the transverse section of the floor, Fig. 2. A special feature of the design which may be noted here is the method adopted for taking care of the grade to make it the least noticeable. This method consisted in making each arch of increasing depth as called for by the grade, but keeping the distance between the upper and lower chords at the center of the arch in each case the same. Had the arches been kept alike and the distances between the chords made to correspond to the grade, it was considered by the designers that the effect would not have been so good; as the change in grade between two arches would have been emphasized by this changing distance between the chords.

Fig. 4.—Plan of Lenawee Junction, Mich., L. S. & M. S. Ry. (Showing Signals).

The metalwork was proportioned for the following requirements:

(1) The floor beams and stringers are to carry a loading of 100 lbs. per sq. ft. over all parts of the sidewalk and driveway or a 20-ton load on a wheelbase of 9 ft. on any part of the driveway; and for 1,000 lbs. per lin. ft. of the railway tracks, or an electric car weighing 25 tons loaded followed by another car weighing 20 tons loaded, on a total wheelbase of 78 ft.

(2) The trusses are to carry the full area of the sidewalk and driveway over the whole span loaded with 80 lbs. per sq. ft., and 1,000 lbs. per lin. ft. over each railway track. The dead load was assumed to be 7,800 lbs. per lin. ft.

The strains induced by this loading are shown for one of the main arch ribs by Fig. 3, which also shows the panel arrangement, web system and end bearing construction in a general way.

Taking up one of the main arches more in detail, it will be seen that it is composed of three parallel ribs spaced 28 ft. apart c. to c. A stiff lateral system braces the ribs together in the plane of the bottom chord. The top chords are braced laterally only by the floor system, which, as will be seen later on, is an unusually stiff one. The web and chord connections are all riveted rigidly; with pins at center and ends. Fig. 4 shows the principal details of the center connection and one adjacent panel, and Fig. 5 similar details of one end bearing and the three adjacent panels. These drawings explain themselves.

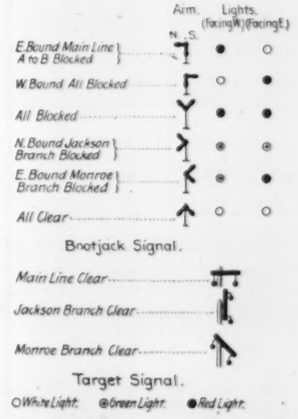


Fig. 5.—Positions and Colors of Bootjack and Target Signals at Lenawee Junction.

It will be noticed from Fig. 3 that the ends of the arch ribs are carried by steel shoes and bearing plates. The bearing plates of 1½-in. wrought

steel were anchored to the masonry first and the location of the steel shoe castings fixed on the plates after all the piers were finished. The holes for the anchor bolts connecting the shoe castings to the bearing plates were drilled by template after the exact location of the respective shoes had been determined. This construction proved to be very efficient, not the slightest movement being noticed in swinging off the arches.

The floor construction is shown clearly by Fig. 2. It will be noticed that the roadway and sidewalk have buckle plate floors with concrete filling, making a very stiff lateral bracing. The portion carrying the electric railway tracks has the ordinary floor beam, stringer and cross tie construction of railway bridges, but between each pair of the main floor beams, shown by Fig. 2, there is introduced an intermediate beam covering just the width of the railway tracks.

The method of erecting the bridge by falseworks is clearly shown by Figs. 6 and 7. These two engravings, made from photographs taken May 7 and May 18, respectively, also indicate the rapidity of erection. In about one month's time the three main spans were erected nearly complete, including the floor system and trolley tracks. Concerning the plan of erection, it will be noticed from Fig. 6 that the lower chords of the arches were first connected complete on the falseworks, including the bracing, and then the web members and upper chords were put in place panel by panel. This plan was found to be quicker and better, and was much easier on the falseworks, than the plan of erecting the bridge by putting in place a complete panel at a time, proceeding from one end to the other. It practically eliminated any pushing of the falsework due to loading one side first.

As an example of careful shop work, as well as for its rapid erection, this bridge is worthy of notice. Each arch is different, including all members, and although the metal work was not assembled in the shop before shipment the foreman of erection states that every joint and detail came together perfectly and without the least trouble.

In the foregoing, attention has been called very briefly only to the principal constructional features of this bridge, but a great many minor details of interest are shown by the drawings. For the matter from which this description and the illustrations have been prepared we are indebted to the Phoenix Bridge Co., Phoenixville, Pa., Mr. John Sterling Deans, M. Am. Soc. C. E., Chief Engineer.

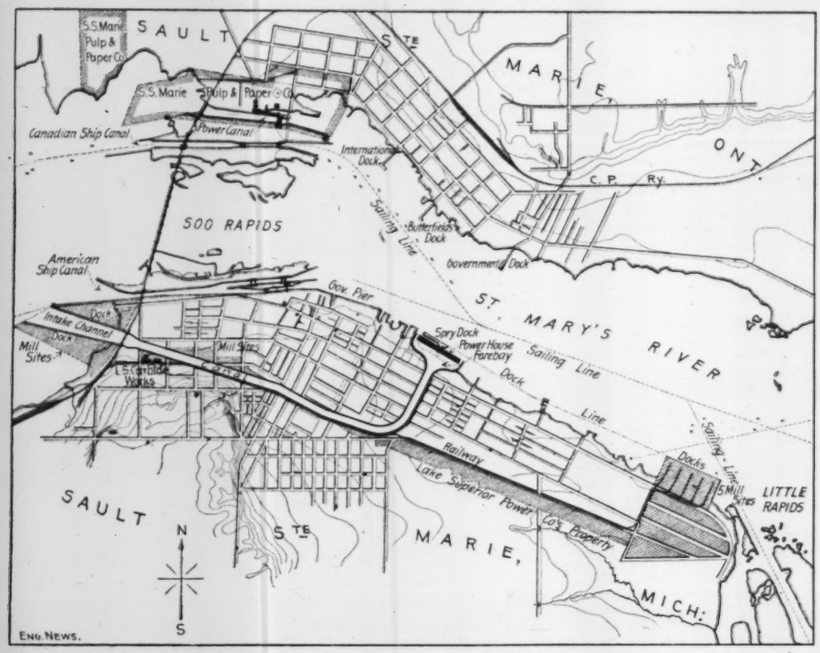


FIG. 1.—MAP SHOWING WATER POWER PLANTS OF THE LAKE SUPERIOR POWER CO., AT ST. MARY'S FALLS, MICHIGAN.

H. von Schon, Sault Ste. Marie, Mich., Chief Engineer.

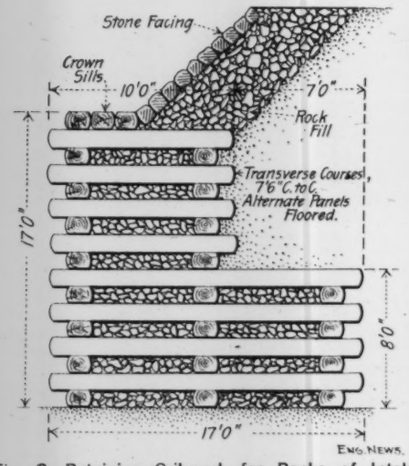


Fig. 2.—Retaining Cribwork for Banks of Intake Channel in Earth.

WATER POWER DEVELOPMENT BY THE LAKE SUPERIOR POWER CO., AT ST. MARY'S FALLS, MICH.

The possibility of utilizing the 18-ft. fall in the St. Mary's River at Sault Ste. Marie, Mich., for developing water power has long been recognized, and various different attempts have been made in the past to organize and carry out a broad plan of utilization. None of these plans reached a very advanced stage on the American side of the falls until recently, but on the Canadian side a large amount of work has been done during the past three years. The work of water power development on the Canadian side was first taken up, we believe, by the town of Sault Ste. Marie, Ontario. The town was, however, unable to raise the money necessary to carry the work to conclusion, and some four years ago it disposed of its interests to the Lake Superior Power Co., composed of a syndicate of Eastern capitalists, headed by the following officers: President, E. V. Douglas, Philadelphia, Pa.; Vice-President, F. H. Clergue, Bangor, Me.; and Treasurer, W. P. Douglas, Philadelphia, Pa. The company's headquarters are at 1420 Chestnut St., Philadelphia, Pa.

At about the same time, 1894, the same company secured the rights for water power development on the American side, but it first began the actual work of construction on the Canadian side. Here it completed a canal about 2,000 ft. long, 125 ft. wide, and 14 ft. deep, with all the necessary constructions for developing 20,000 HP. To use this power, two 40-grinder pulp mills were erected, one being completed in the fall of 1896, and the other during the following summer of 1897. The location of these mills, the canal and the other property of the company on the Canada side is shown by the map, Fig. 1, and this work will not be referred to again here.

On the American side of the river the work had, of course, been progressing in securing property and developing plans for the proposed improvement, but it was not until the present year that actual construction was begun. In fact the work might have been delayed still longer had it not been for the development of the calcium carbide industry. In 1896, Mr. Geo. O. Knapp, of Chicago, Ill., with the co-operation of the Lake Superior Power Co., erected at Sault Ste. Marie, Mich., the Lake Superior Carbide Works, for the manufacture of calcium carbide. This finally led to the organization of the Union Carbide Co., which controls the manufacture of calcium carbide over a large portion of the United States, and this company proposes to concentrate the manufacture of its commodity at Sault Ste. Marie. At the very outset, the company will require some 20,000-HP. (electrical) for its new works, and this power the Lake Superior Power Co. has contracted to supply. The remaining power to be developed will be largely consumed, it is expected, in the electrical reduction and concentration of the various copper and nickel ores in which the country to the north of the "Soo" is so rich. With this brief explanation, attention may be given to the plan proper for developing the water power of the St. Mary's River on the American side of the falls.

The St. Mary's River, as most of our readers know, is the outlet for the waters of Lake Superior into Lake Huron, the mean discharge at the rapids being about 90,000 cu. ft. per second. The mean elevation of Lake Superior is 601½ ft., while that of the river below is 582 ft., making a fall of 19½ ft. in a distance of about 3,500 ft. The general scope of the Lake Superior Power Co.'s project is to divert such a portion of the discharge over the most direct and economical route as will yield 40,000 HP. at the turbine shaft. To accomplish this it will excavate a canal through the village of Sault Ste. Marie, Mich., along the route shown by Fig. 1, and at its lower end erect a power house with the necessary turbines and electrical generators.

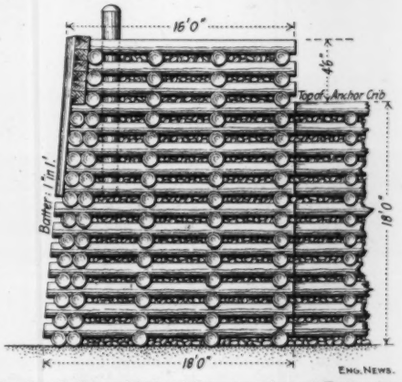


Fig. 3.—Bulkhead Wharf Construction at Entrance of Intake Channel.

Canal.

Location.—The right of way secured for the canal was primarily the location selected some ten years ago by one of the early companies organized to develop the water power of the river. In a measure, this early location, or a portion of it, is the logical one. The present canal location, there-

fore, follows the old location for about 6,000 ft., then curves to the north to an outlet. The old location continued nearly straight ahead, as shown by the dotted lines bounding the company's property, to an outlet some two miles or more below the falls. Fig. 1 shows clearly the present location.

The general location having been selected the next step was to determine the necessary dimen-

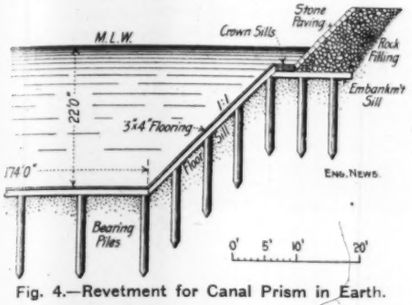


Fig. 4.—Revetment for Canal Prism in Earth.

sions of the canal. It was found that for about 3,000 ft., beginning at the west end, Potsdam sandstone came to the surface, and thence for the remaining distance the formation was sand, gravel, clay and boulders in undefined and irregular deposits, the sand, however, largely predominating. For nearly two-thirds of its length, therefore, the material penetrated by the canal would not endure undisturbed a velocity greater than 3 ft. per second. Such a flow would require a sectional area in the canal prism of about 10,000 sq. ft. or a width of canal of from 450 ft. to 500 ft. This width was out of the question. The land adjacent to the canal location had become settled and built upon, and the real or imaginary value fixed upon it by its owners, prohibited any thought of requiring much of it for right of way. The only solution was to narrow the canal and so protect its banks as to permit of a velocity of flow approximating that which could be safely maintained in the rock cut. This velocity was set at 7½ ft. per second.

The canal capacity was based upon the final development of 40,000 HP. on the shaft of turbines yielding 80% efficiency with seven-eighths water. The volumes of water required to be diverted to attain this result was $\frac{504,473}{Vh}$, in which V is the velocity of 7½ ft. and h is the effective head, which was found to be 16.2 ft., or a volume of 4,200 cu. ft. per second. Adopting an excess of area of 5% and the coefficient of friction, n, of 0.02, this made the necessary rectangular section in rock

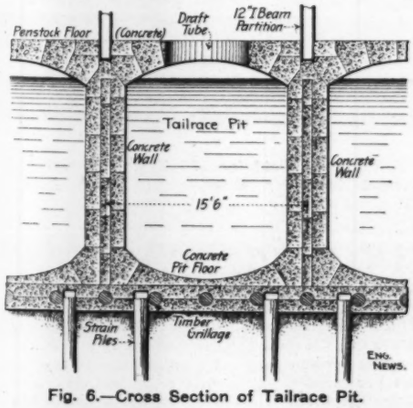


Fig. 6.—Cross Section of Tailrace Pit.

200 × 22 ft. For earth, adopting an excess of area of 2½% and a coefficient of friction of 0.015, with side slopes of 1 on 1, the necessary section was 22 ft. deep, 174 ft. wide on the bottom, and 218 ft. wide at the top. These sections were, therefore, adopted for the main part of the canal; there being a widening at the head to form an intake and another at the foot to make a forebay.

The intake is 2,400 ft. long and leads through a shallow bay to the navigable channel in the St. Mary's River. Here the prism is gradually widened to 500 ft., the sides being cribwork. The forebay at the terminal of the canal is about 1,400 ft. wide and is closed by the power house, as shown by Fig. 1.

For purposes of construction the work is divided into the Intake Section, Canal Sections I., II. and III., the Forebay and the Power House. The description of the work will follow the same order of division.

Intake.—The intake section extends from the harbor line on the west, east to the river shore, traversing Ashmun Bay, a shallow sheet of water generally from 3 ft. to 5 ft. deep. This section is about 2,400 ft. long, its eastern section being mostly in sandstone rock and the western section in sand, gravel and boulders. The rock portion is to be cofferdammed, and a rectangular channel 200 × 22 ft. is to be excavated dry. The western portion is to be gradually widened to 500 ft. at the entrance and dredged to a depth of 18 ft. The sides of the dredged channel are to be retained by log timber cribs with stone paved earth embankments, except near the western terminal, where bulkhead wharves 600 ft. long will be built.

The general construction of the retaining cribs is shown by Fig. 2, and is described more in detail in the specifications as follows:

The material is to be of hemlock, tamarack or Norway pine logs, faced on two sides to uniform thickness of 12 ins., laid in alternate longitudinal and transverse courses upon each other in crib form. The bottom course of the structure is a longitudinal of 12-in. timbers 30 ft. long, laid 7 ft. centers and is to rest on the channel bed in a horizontal plane, being 18 ft. below the datum plane. Upon it are laid transverse timbers 12 ins. thick and 17 ft. long, 7 ft. centers. The construction continues upward in this manner to a height of 8 ft. from the bottom, where it narrows, the upper four longitudinal courses consisting of only two rows of 12-in. timbers, the transverse timbers being 10 ft. long. The longitudinals in front and rear row are laid with butt joints and in center row pass by 7 ft. All timbers at crossings are spiked with ¾-in. × 20-in. drift bolts and all joints and laps are bolted every 2 ft. This construction terminates with a longitudinal course consisting of three 12-in. timbers laid close to the face of the crib, with top surface 16 ft. from bottom or 2 ft. below water surface, serving as heel sills for the stone paved bank, rising from this elevation to a height of 5 ft. above water surface on a slope of 1 on 1. The bottom transverse course in each alternate crib bay is floored with closely laid 12-in. logs, each spiked at crossing to each longitudinal timber with one ⅞-in. × 20-in. drift bolt. The cribwork is to be filled with stone ballast selected from rock excavation, no piece exceeding 1 cu. ft., and with chips and gravel to fill the voids between larger stones; and the back of the structure is to be filled with similar material to a height of 5 ft. above water surface. All this filling is to be in layers. The front slope of the filled space above the cribwork is to be paved with selected stones at least 12 ins. deep, set on edge by hand, close to each other, and so fitted that they will form a solid close-jointed pavement, resting at the foot against the toe log and being capped with larger flag stones all firmly imbedded into the bank.

The general construction of the bulkhead wharves is shown by Fig. 3, and is described in detail by the specifications as follows:

The bottom course of the structure rests on the channel bed in a horizontal plane, 18 ft. below datum plane, and is composed of four longitudinal 12-in. log timbers 30 ft. long, laid 5 ft. centers. Upon it are laid the transverse courses of 12-in. log timbers 18 ft. long and 7.5 ft. centers. The timbers in these two bottom courses are gained into each other at crossings 3 ins., so that the top surface of the transverse timbers is 1 ft. 9 ins. above foundation of structure. This construction continues upward except that all upper longitudinal timbers are 9 ins. thick, and that at crossings the transverse timbers only are gained for 1½ ins. The length of longitudinals is uniformly 30 ft. and they are laid butt to butt in front and rear rows, joints and splices are spiked with similar drift bolts set from opposite sides and at intervals of 2 ft. This construction continues upward to 4 ft. 6 ins. above upper level, with the exception that the front row of longitudinals above water surface is of square-sawed white pine facing timbers.

The bottom facing timbers are 12 × 12 ins. × 26.5 ft., laid with 4-ft. scarf joints on bevel face to follow face batter and upon them are laid four courses of 10 × 12-in. × 30 ft. 8 ins. or 40 ft. long on 12-in. faces with butt joints. The cap facing timber is of 12 × 12 ins. × 34 ft. or 40 ft. long laid with 4-ft. half lap joints. All scarf and lap joints are tied by two 1 × 14-in. drift bolts; and facing timbers are secured to each other by ⅞-in. drift bolts of sufficient length to set through 2½ timbers, driven every 4 ft. The front ends of the transverse timbers above water surface are to be dovetailed into the square facing timbers, the dovetails to be not less than 6 ins. deep by 8 ins. wide, neatly cut, leaving square cut sawed shoulders on the ties and to fit up well against the facing timbers. The dovetailed ends are secured to the facing timbers, each with one ¾-in. round-pointed drift bolt, 16 ins. long. Half-round oak fenders are placed on each side of the exposed ends of the crossties, the top of fenders being flush with top of bulkhead. Mooring posts are placed in bulkhead every 50 ft. A close log floor is laid in each alternate crib bay upon the second longitudinal course from the bottom.

Five anchor cribs 20 ft. long (transversely), 22.5 ft. wide

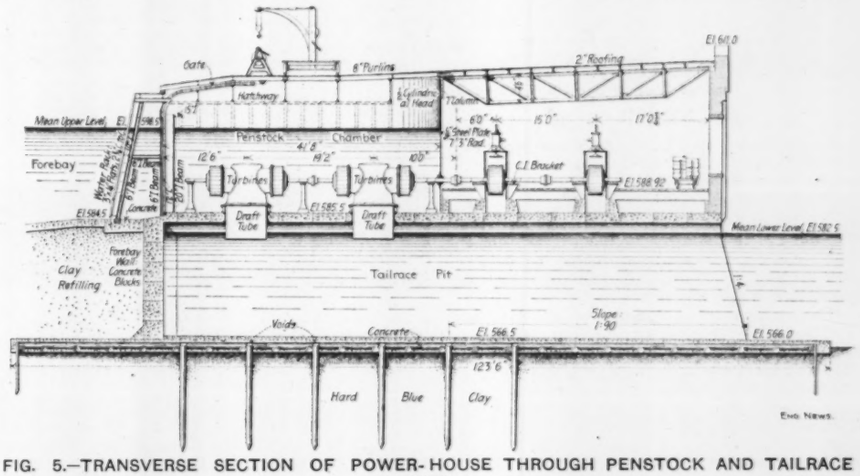


FIG. 5.—TRANSVERSE SECTION OF POWER-HOUSE THROUGH PENSTOCK AND TAILRACE PIT.

(longitudinally) and rising to water surface, are placed in rear of the main bulkhead. Their construction is the same as that of the main bulkhead, consisting of alternate longitudinal and transverse log timber courses. There are four longitudinals, 5-ft. centers, 24.5 ft. long, and four transverse timbers running through from front face of main bulkhead to rear of anchor crib in one length. These courses are laid and joined in the same manner as described for the main bulkhead and are all floored on the second longitudinal course as described for alternate bays in the main structure; two anchor piles are to be set in each unfloored bulkhead bay against the rear longitudinals, and stone ballast is to be placed in the entire bulkhead structure.

The work of excavation proper in the intake section calls for brief mention only. As stated,

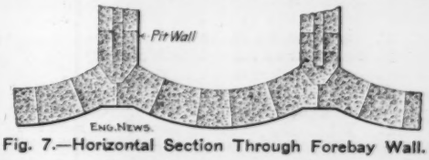


Fig. 7.—Horizontal Section Through Forebay Wall.

the western portion is dredging. The eastern portion inside the cofferdam is dry excavation in rock, overlayed by sand, gravel and boulders. There will be about 115,000 cu. yds. of solid rock and 152,000 cu. yds. of other material in this dry excavation. In rock the sides of the prism are to be cut with channelling machines.

Canal Sections I., II. and III.—This portion of the work consists of the following excavation:

Section.	Dimensions of prism, ft.	Length, ft.	Not rock, cu. yds.	Rock, cu. yds.
I.	200 × 22	2,900	23,000	532,000
II.	22 × 174 and 218	2,900	710,000	.....
III.	22 × 174 and 218	3,100	780,000	.....
Total		8,900	1,513,000	532,000
Grand total of excavation				2,045,000

Besides excavation, this work comprises the necessary constructions for retaining the banks. In the rock portion this consists in constructing a retaining wall 3½ ft. wide at the bottom, and 2½ ft. wide at the top, where the top of the natural rock falls below the requisite height of the canal banks, and in remedial construction to be applied to the canal sides where the rock formation is found to be faulty. It is estimated that there will not be more than 350 cu. yds. of retaining wall.

The protection of the earth prism will consist of a timber revetment on the bottom and sides, con-

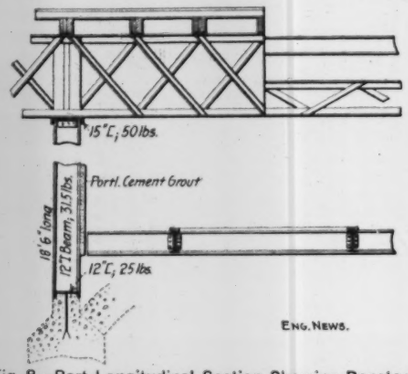


Fig. 8.—Part Longitudinal Section Showing Penstock Construction.

structed as shown by Fig. 4. The bearing piles are driven in rows spaced 5 ft. apart, and running transversely across the canal, and they carry log timber sills faced to a uniform width of 12 ins. and drift bolted to each pile. The space between sills is filled with puddle. On top of the sills is laid a floor of 3 × 4-in. timbers. The other details of construction are sufficiently explained by the drawing, Fig. 4.

Forebay.—The forebay consists of the gradual expansion of the channel at the termination of Section III. by similar curves east and west to a width of about 1,400 ft. The length varies from 150 ft. to 300 ft. The power house closes the front of the forebay. The whole area of the forebay will be inclosed by triple-lap sheet piling, and its banks will be riveted in a manner similar to the earth sections of the canal proper. The amount of excavation called for, including that for the power house foundations, is 235,000 cu. yds. of mill waste, sand, gravel and clay.

Power House.

Foundations.—The foundation area of the power house is about 1,367 ft. × 125 ft., and the foundation consists of a timber grillage placed upon a bed of stiff clay and resting upon piles. A row of triple lap sheet piling surrounds the grillage, which is also filled and covered with concrete to a depth of 6 ins. above the tops of the log caps. This construction is shown in a general way by Fig. 5, which is a transverse section of the power house through the center of the penstock and of the tailrace pit underneath it. This section also shows the arrangement of the turbines and dynamo coupled to a single horizontal shaft, and it may be stated here that there are 85 of these units in the power house.

Tailrace Pits.—Upon the timber grillage foundation are erected the pit walls 3 ft. thick and 15½ ft. apart c. to c. These walls extend for 96 ft. transversely across the foundation grillage. At the bottom between the walls are sprung inverted arches forming the pit floors, and at the top is the roof, which is a series of circular arches with spans of 12½ ft., rises of 2 ft. and a thickness at the crowns of 1½ ft. This roof has circular openings lined with steel collars for the turbine discharge, and covers only 43 ft. of the pit length, or the length of the penstock chambers. The inner ends of the tailrace pits are closed by an arched forebay wall 18 ft. high. In this manner the tailrace pits are entirely enclosed except at their outer ends, where the water is discharged.

Fig. 6 is a transverse section of one of the tailrace pits showing the wall, floor and roof construction just described, and Fig. 7 is a horizontal section of a small portion of the arched forebay wall closing the inner ends of the pits.

The construction of the pit walls, forebay wall and pit roof is of Portland cement concrete blocks laid in cement mortar, and that of the pit floors is monolithic Portland cement concrete. Altogether about 28,500 cu. yds. of concrete are required in the work, of which 23,730 cu. yds. will be in 14,400 blocks. The use of so much concrete block masonry in rather trying positions makes the specifications for the cement employed of more than usual interest, and their principal requirements are abstracted here:

The inspection of the cement will be in 100-barrel lots. Ordinarily cement will be taken for testing purposes from 10 barrels out of each 100 lot, selected at random, and the failure of any of this cement to come up to all the requirements will be considered sufficient cause to reject the lot of 100 barrels of which the faulty cement is a part. The inspection tests to which the cement is to be subjected will be made as follows:

(1.) To determine the time of initial setting cement will be mixed for three minutes with about 30% of water so as to make a stiff paste and then spread upon a glass plate to a thickness of about 1½ ins. Whenever this cement paste resists a slight pressure exerted by a finger nail it will be considered to have taken the initial test.

(2.) To determine the constancy of volume mixed neat cement will be made into wedge-shaped pats about 3 ins. on a side, ½-in. thick at back and tapering to a feather edge. This pat will be kept in a box protected from draft or sun and covered by a wet cloth for 24 hours and then laid in water of ordinary temperature where it will be kept and examined for a period of 28 days.

(3.) To determine the fineness the cement will be sifted through a No. 100 sieve; that is, 100 holes per lin. in.

(4.) To determine the tensile strength 20 briquettes of the cement lot to be tested, 10 of neat cement and 10 of three parts of standard Point Aux Pins sand, will be made and tested in accordance with the methods approved by the American Society of Civil Engineers as far as they relate to the preparing, preserving and breaking of the briquettes.

The requirements to be fulfilled by the cement in order to be accepted for this construction, as evidenced by the results of the inspection tests, are:

(1.) That the time of initial set is not less than one hour.

(2.) That the cement pats made for the constant volume test, exhibit no warping, cracking or other unsoundness after being in air or water of ordinary temperature for 28 days.

(3.) That the cement is of such fineness that at least 90% will pass a No. 100 sieve.

(4.) That the minimum tensile strength per sq. in. as per average of ten neat cement briquettes after 28 days of age (1 day in air and 27 in water) shall be 700 lbs., and of the three parts of sand briquettes of the same age and exposure, 300 lbs.

In regard to the manufacture of the concrete blocks the specifications are as follows:

The filling of the molds is to be done in molding sheds as close to the point where the concrete is mixed as practicable. The molds may be of any construction the contractor selects, provided they are of the true forms and dimensions required for the blocks and that they are lined with sheet iron on the inside. They may be bottomless provided they are placed upon sufficiently heavy and smooth platforms. Before the concrete is deposited in the molds each part of the mold which will come in contact with the concrete is to be thoroughly cleaned and covered with a thin coat of a good grade of machine oil. The molding of any one block must not be interrupted but is to be completed as rapidly as practicable without any intermission in the depositing and compacting of the concrete. The exposed surfaces of the block are to be molded out of the finer material contained in the concrete mass and this is to be compacted by special steel-shod oaken rammers having a face of ¼-in. × 5 ins. The filling is to be carried slightly over the top surface of the mold and a cover sufficiently heavy is to be forced upon the top so that the surface becomes perfectly leveled off and smoothed. A cement label in accordance with the engineer's directions is to be inserted in the top of each block upon its completion. The sides of the mold may be removed 48 hours after the block is molded but no sooner, and the block is to remain upon the molding platform at least 15 days, during which time it must be shaded from sunlight, kept wet by sprinkling, and protected against freezing temperature. After this period blocks may be removed to storage where they may be piled provided they rest on 2-in. planks and they are to be protected from weather and temperature below 36° F. for 15 days more. Blocks which have attained an age of 30 days and are accepted by the engineer may be laid in the structure for which they are designed.

The laying of the concrete blocks will be in all respects governed by such rules and methods as are usually adopted in laying first-class ashlar masonry.

Penstock.—The penstocks are located directly over the rear ends of the tailrace pits, as shown by Fig. 5, and consist of a floor, which is also the roof of the tailrace pit below, partition walls, cylindrical steel bulkheads closing the inner ends, and a trussed roof. Fig. 8 shows the partition wall, floor and roof construction, and Fig. 9 shows the bulkhead construction. It will be noted that the partition walls consist of a framing of I-beam posts with channel sills and caps filled

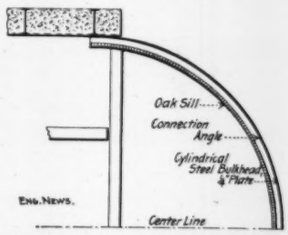


Fig. 9.—Horizontal Section Through Penstock Bulkhead.

with Portland cement grout. This filling will be done between timber forms having a clear inside width of 1 ft. 5 ins.

The bulkhead is semicircular and is fastened to the walls and floor, as shown by Fig. 9. It is 14 ft. 6 ins. in diameter, and is made of ¼-in. steel plates connected by double riveted lap joints. The ends of the penstocks opposite the bulkheads are open into the forebay. Five of the penstocks are also arranged for spillways, and have a discharge capacity equal to the full amount of the water diverted by the canal.

Each penstock is closed by a rolling gate of the construction indicated by Fig. 5, and has a water rack to prevent the access of drift. A movable headgate of the wicker dam type will also be erected at the terminal of the canal proper, its superstructure being a highway bridge.

Mill.—The mill proper occupies the front portion of the power house, and contains the electric gen-

Fig. 10.—Lower Half of Stationary Armature for Single-Phase Alternating Current Generator.

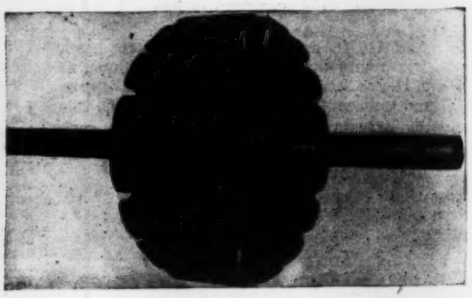


Fig. 11.—Rotating Field for 375 K-W. Alternating Current Generator, Built by the Walker Co., Cleveland, O.

erators. The two pairs of turbines in each penstock have a capacity of 500 HP. at 250 revolutions. These are mounted on a single horizontal shaft, to which the 375-K-W. slow motion dynamo is also attached.

These generators, which are to be built by the Walker Co., Cleveland, O., operate at 200 volts and 60 cycles per second when running at 240 revolutions per minute. Ten exciters of 100 HP. each will be installed, and these will be belted to the turbines in such manner that each exciter can be operated by either of two turbines. The generators have stationary armatures, as shown in Fig. 10, with an interior revolving field magnet, which is a massive cast-iron split hub provided with steel ring tires, to which are bolted the 30 outwardly projecting laminated pole pieces. These are wound with a flat copper ribbon conductor, wound edge on, and insulated with shellacked

paper. The winding is placed upon a suitable spool which is slipped on the pole piece and securely clamped when the pole piece is bolted down. These bobbins are connected in series, the ends running to the two rings, seen in Fig. 11, which permit the exciting current to reach the coils while the field is revolving. The armature consists of a large ring built up of sheet iron stampings, notched to form slots for the armature coils. These sheets are clamped together in semi-circular cast-iron side pieces, which are hollowed for ventilation, and the two halves are finally bolted together. The armature coils are wound on forms and carefully insulated, being afterwards slipped into slots, clamped into place and connected up. The current will be used in the carbide furnaces, consisting of 6 furnaces in multiple on four machines, and as only four furnaces out of the six will be in use at any one time, each furnace will take the full output of a machine, or about 1,800 amperes at 200 volts.

The mill house proper is built of sandstone masonry, with a steel truss roof and steel interior framing. Fig 5 shows this construction in a general way.

In conclusion it may be interesting to some of our readers to give the total amounts of the different kinds of work and material which will be required in constructing the plant. They are as follows:

Excavation:	
Solid rock, cu. yds.	650,000
Other material, cu. yds.	2,200,000
Log timber, ft., b. m.	15,000,000
Squared timber, ft., b. m.	7,000,000
Structural steel, tons	2,400
Bolts and spikes, tons	300
Portland cement, barrels	70,000
Sandstone masonry, cu. yds.	40,000
Sand, cu. yds.	25,000
Brokenstone, cu. yds.	60,000
Turbines	320
Dynamos	80

According to the present plans, all work of construction is to be completed in two years. All the plans and specifications of the work have been prepared under the direction of Mr. H. von Schon, Chief Engineer, Lake Superior Power Co., Sault Ste. Marie, Mich. We are indebted to Mr. von Schon for the information from which this description has been prepared, and also to "The American Electrician" for Figs. 10 and 11 and the material from which the description of the electrical apparatus was prepared.

THE WALKER CONDUIT ELECTRIC STREET RAILWAY SYSTEM.

The satisfactory working of the Metropolitan conduit electric railway in Washington, D. C., and the Lenox Avenue line in New York city, marked a new era in city street railway construction. The system thus practically tested has undoubtedly come to stay, because it meets the engineering requirements and also embodies the one feature long desired by municipal authorities, namely, freedom from any overhead construction.

The two roads just mentioned have now been in operation about three years, and their continued success is a final answer to the stock statement that conduit roads cannot be made to operate successfully or economically. As a result, we may expect to see many city street railway companies following the example of the Capital Traction Co., of Washington, or the Metropolitan, of New York, and either of their own accord, or under compulsion by city authorities, change their lines from horse, cable or overhead trolley to the conduit system.

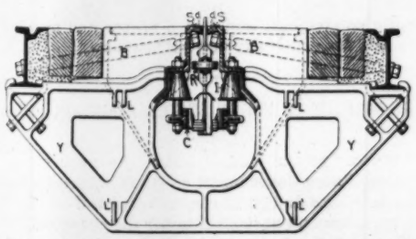


Fig. 1.—Section of Track Showing Yoke, Conduit Insulators and Plough

Anticipating this demand, likely to occur in the near future, the Walker Co., of Cleveland, O., has developed a conduit system embodying the successful features of the present systems and introducing such new ideas as experience has made expedient.

To the casual observer the conduit of this system appears the same as those first mentioned; substantial cast-iron yokes spaced about 5 ft. apart support deep girder rails and the usual slot rails. Inside the conduit are two T-shaped conductor rails, about 6 ins. apart and 14 ins. below the street surface, while every 15 ft. are the familiar cast-iron hand-hole lids.

Fig. 1 represents a section of track using the Walker conduit construction. The yokes, Y, are

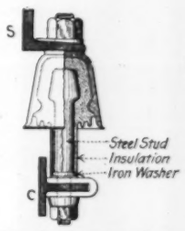


Fig. 2.—Section of Insulator for Supporting Conductor Rails.

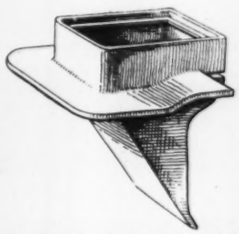


Fig. 3.—Cast Iron Hand-hole for Access to Insulators.

cast with large broad steps, but are light in weight, owing to the method of distributing the metal, the webs being cast thin, but deep. They are all of the same pattern, thus preventing any delay during construction work which would result from waiting for special yokes. Suitable steps are provided at the ends for supporting the rails, which are securely locked into place by hook bolts, as seen in the figure. The slot rails, S, S, are bolted to the yokes in the usual way and are braced by the flat tie rods, B, B. The insulators, I, I, Fig. 2, consist of an outer bell-shaped malleable iron shell and a straight steel shank threaded at the lower end and held in the bell by an insulating material, said to be superior to porcelain on account of its elasticity. This is formed around the knob of the rod and shoulder of the bell by pressure. These insulators are bolted to the foot of the slot rails a little to one side of every third yoke, that is, 15 ft. apart, and a cast-iron hand-hole frame, Fig. 3, is bolted to the slot rail and the yoke in the proper position to afford access to the insulator. To the lower end of these insulators the conductor rails, C, C, are bolted, the bolts passing through the web of the conductor, thus avoiding the long cast-iron offset heretofore used. These T-rails are 3 × 2½ ins., and have a cross section of about 250,000 circular miles. They weigh 18 lbs. per yd. and are rolled in 30-ft. lengths, thus bringing a joint at every third hand-hole, where two No. 0000 copper bonds are employed. The line is divided into insulated sections, varying from 500 to 800 ft. in length, which are connected together by a system of switches placed in suitable manholes under or at the side of the track, so arranged that any trouble can be easily located and confined to a short section of the line. Taps are taken off from the feeders at frequent intervals, and these are also controlled by switches.

Construction work is facilitated by the lugs, L, L, cast on the yokes, into which boards are slipped to form a backing for the concrete of the conduit. In this way just the proper thickness of material is maintained with no waste. To prevent any possibility of the breaking-in of the concrete forming the arch at the top of the conduit, steel plates, shaped in rolling so as to hang on the foot of the slot rail and rest upon suitable lugs cast upon the yokes, are employed. The finished conduit is 16 ins. wide and 24 ins. deep from the upper surface of the slot rail to the bottom.

The plough employed, shown in Fig. 2, differs only in details from that used on the systems now in operation. It consists of two ¼-in. steel plates, bolted together, at the lower end of which are bolted two pieces of wood about 18 × 6 ins. by about ⅞-in. thick. The cast-iron contact shoes are mounted upon springs, as shown, and are connected through copper fuses to the leads, which run up in grooves between the steel plates to contact strips on an insulating block, H, at the top. Just where the hanger would wear against the sides of the slot tempered steel pieces are inserted. A few inches below this, two rollers are strongly mounted upon the hanger, their purpose being to bear against the foot of the slot rail, as seen in Fig. 1, and thus prevent any great strain on the conductor rails in rounding curves, or should the car run on a switch or off the track. To attach the plough to the car, a cast-iron clamp bar is bolted to the steel plates previously mentioned. This is proportioned so as to have ample strength under ordinary working conditions, but will break from any undue strain and permit the plough to drop free of the car. To facilitate this, connection from the car to the plough is made through a box, J, provided with contact springs which press against the strips on H. If the plough drops or it is desired to break connection the box is slipped off.

Comparing the section given in Fig. 1 with the section of the conduit roads now in use (Eng. News, Feb. 24, 1898, Fig. 4), several differences will be observed. The first, and possibly the most important, is the substitution of a molded compound in the insulator in place of porcelain, thus considerably reducing the size. The second, resulting from the reduction of size, admits of the insulator being bolted to the foot of the slot rail, thus saving the boring of one hole and the use of two bolts for each insulator, and lastly, as the insulators are now close together, the cast-iron offset is dispensed with, thus effecting a saving to that amount. The insulator stud is bolted directly to the web of the conductor rail, practically

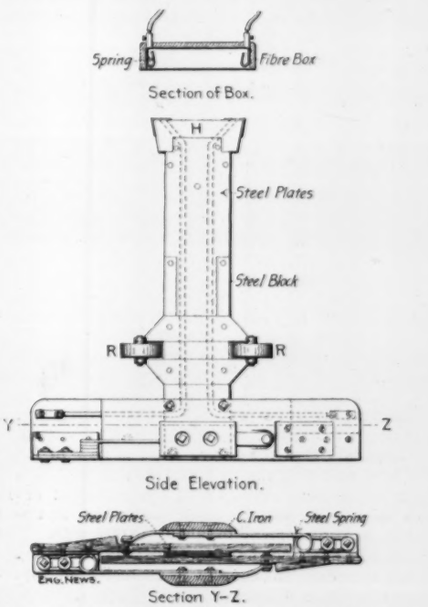


Fig. 4.—Walker Plough and Details of Construction.

at its center of gravity, and consequently the strain on the insulator is simply the dead weight of the conductor rail, except when a car is passing. At such times there is a side strain due to the pressure of the plough springs.

A WATER TANK AT DALLAS, TEX., is reported as having failed on Aug. 1, fatally injuring a man engaged in finishing it. The tank was to be used for private fire protection and was on a tower 65 ft. high. It had a capacity of about 30,000 gallons and had just been filled.

ELECTRIC LOCOMOTIVES for operating the mountain divisions of the Central Pacific Ry. are said to be under consideration. It is believed that sufficient water power can be obtained from the mountain streams in the vicinity of the line to generate the current, and it is proposed to operate the road in this way from Sacramento east across the Sierra Nevadas to Verdi, Nev., a distance of 144 miles. While the above is only newspaper rumor, the high price of coal on the Central Pacific makes the story one which is not at all improbable.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.

Published every Thursday

at St. Paul Building, 220 Broadway, New York, by

THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, } ASSOCIATE EDITORS.
CHAS. S. HILL, J. J. SWANN, }

A. B. GILBERT - - - - - - - ASSISTANT MANAGER

CHAS. W. REINHARDT, - - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York, }
F. A. PECKHAM, Chicago, } ADVERTISING REPRESENTATIVES
S. B. READ, Boston, }

PUBLICATION OFFICE, ST. PAUL BUILDING, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current year, 15 cents.

Mailing addresses may be changed at will by sending both old and new address. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 328 means that subscription is paid to the 32d week (that is the issue of Aug. 11) of the year 1898; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 18. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

We noted in our last issue the issue of a supplementary circular by the Navy Department announcing that in considering bids for the three new battleships, preference would be given to designs promising the highest speed, in connection with good steaming radius. Apparently the Navy officials have come to feel, however, that this plan will not give the new vessels such speed as they should have to keep the country abreast of foreign nations, and according to Washington dispatches of Aug. 1, Secretary Long has proposed to the Board of Construction that the present call for bids should be withdrawn, and entirely new designs should be prepared which will give the ships greater speed.

It is said that the Board itself is now in favor of this, and that the new vessels will be designed for a minimum speed of 18 knots instead of 15 as at present, will be copper sheathed, and will have a displacement of about 13,000 tons. The cost will be somewhat increased; but it is hoped that Congress will consent to an increased appropriation when it reassembles.

If this plan is carried into effect, the country will have renewed reason for its confidence in Secretary Long as the most able head that the Navy Department has had in many years.

The accuracy of the shop work habitually turned out by some of the better bridge shops of this country is sometimes, it seems to us, not so fully appreciated by engineers as it might be. As an instance of such careful workmanship we may call attention to the three-span steel arch bridge across the Schuylkill River, in Fairmount Park, Philadelphia, Pa., which is quite fully described elsewhere in this issue. The fact that in a structure of this magnitude where each arch differed in all its members, and without any previous assembling of the different parts, every joint and detail was found to fit perfectly upon erection speaks marvels for the perfectness of the shop management and machine work of the modern bridge shop, and it should not fail to receive full recognition. This is, however, by no means an isolated example. Among several which we now call to mind may be mentioned the new 840-ft. steel arch which is being built at Niagara Falls, N. Y., to replace the old footway suspension bridge just below the cataract. The closure of this arch, which took place on April 17, was a notable illustration of careful planning and shop work on the part of the builder, as well as the engineer.

As stated in Engineering News of Feb. 10, 1898, the two halves of the Niagara arch were erected simultaneously from the opposite shores, each half-arch being held back to its adjacent shore by a system of temporary anchor rods attached to alternate panel points of the arch rib until the final connection at the center ensured the stability of the structure by itself. The top anchor rods, that is, those reaching to the panel points nearest the center or crown of the arch, were made strong enough to hold the entire weight of the bridge with the other anchor rods removed, and it was calculated in designing the center connection of the arch ribs that with the weight carried by these top anchor rods alone there would be an opening at the center between the ends of opposite ribs of 2½ ins., at normal temperature. As a matter of fact the amount of this opening proved to be 2¾ ins., with a temperature of 60° F., when the closure was made. Fully as accurate results were obtained in other respects. The arch being of the two-hinge type, with the top chord under a compressive strain, the ends of the top chord were of course the first to close, to be followed by the closing of the arch ribs proper as the strain in the top chord changed from tension to compression under the load. It is plain that if the top chords were thus allowed to close first there might be some difficulty in getting the arch rib to close, and, further, there would be much uncertainty whether the proper apportioning of the strains between the top chord and the arch rib had been secured.

To avoid all this, the builders decided to insure the arch ribs meeting first by the simple means of cutting off the top chords and then, after the ribs had been connected, to force apart the opening in the top chord and insert a cast-steel shim just long enough to replace the metal previously cut off. The various dimensions and pressures involved in this process of closing were carefully calculated at the bridge works before erection and were outlined in a letter of instructions to the company's engineer in charge of erection as follows:

> Each top chord has been made 3 ins. shorter than the figured theoretical length. This would leave in the structure if under no strain whatever, an opening of 6 ins. After the anchor bars have been relieved of all strain and the ribs and their bracing are carried as a three-hinged arch, with a pin at the lower center, this distance ought to be shortened, at an average temperature, by 2¼ ins., leaving a 3¾-in. opening. The weight of the anchor bars which will be carried by the arch will probably increase this opening somewhat. Every rise in temperature of 10° F. will increase the space by 0.2-in. and vice versa. To change the three-hinged arch to the two-hinged arch, the opening at the center ought to be forced back again 2¼ ins., giving a total opening of 6 ins., as intended in the drawings. To do this it will take 360,000 lbs. on one rib, at the average temperature. For every rise in temperature of 10° above the average this strain ought to be reduced by 54,000 lbs. on one rib, which amount corresponds to 0.2 ins. mentioned above. We expect thus, if a pressure is applied, which makes the proper allowance for the temperature, that we will be able to close up the top chords of our arch by planing down 6½ ins. permanent cast-steel shims to 6 ins. or to the amount corresponding to what the top chords have been kept short.

When the closure was made on April 17, the arch ribs came together within ¼-in. of the calculated distance, as stated above. The opening between the ends of the top chords at 60° F., was exactly 3¾ ins., and the pressure registered by the hydraulic jacks in forcing this opening apart the full 6 ins., was 370,000 lbs. for each chord. The lateral adjustment was easily made with crowbars. In other words, the results were almost exactly what they were figured to be. When it is remembered that the accuracy of closure depended, first, upon the accuracy of the calculation and design of the entire steel work; second, upon the exactness with which the bearing shoes or skewbacks were placed, and, third, upon the perfection of the shop work, these results are indeed wonderful. We are not forgetful of the fact that in structures of this immense size and importance the builders doubtless exert themselves particularly, to secure phenomenal results in such particulars as those just described; but nevertheless the combined cunning and efficiency of men and tools which produce these results is an element which does not disappear in the every-day work turned out by them. Where so much important work is left to the honesty and ability of the bridge manufacturer, as is habitually done in this country, this is a matter of no small gratification.

The exact function of bacterial analyses of public water supplies is becoming better understood as time passes and experience accumulates. Unfortunately, many engineers, the majority of doctors, and nearly all laymen still hold mistaken ideas on the subject. We have frequently urged that the isolation of any specific disease germ from the other bacteria in water is a task so difficult and uncertain as to render the attempt practically worthless to the water-works manager. The best bacteriologists freely admit this now, it being a general rule that the higher a bacteriologist stands in his profession the less pretension he makes to being able to differentiate the typhoid bacillus. Thus, Prof. Percy F. Frankland, who has, perhaps, done more than any other man in England to make known and appreciate the value of bacterial examinations of water and the bacterial efficiency of filtration, says

> it is becoming daily more evident that the recognition of specific bacteria is a matter of much greater difficulty than was at first supposed, and the bacteria which are associated with typhoid and cholera are amongst those which offer the greatest obstacles to complete identification.

This quotation is from a paper on "The Chemical and Bacterial Examination of Water," read by Prof. Frankland before the recent meeting of the British Association of Water-Works Engineers. In studying the character of water supplies it is very true, as Prof. Frankland says, in concluding his paper, that

> it is not only necessary that a particular sample of it submitted to an expert shall be free from danger, but that it shall be derived from a source which is capable of continuously yielding, year in, year out, a safe and wholesome product, and in order to secure this end he will have to make use of all the independent evidence which is available: (1) That which is obtained from careful inspection of the source; (2) that which can be furnished by chemical analysis; and (3) that which is afforded by the bacteriological examination of the water. And the special value of the bacteriological evidence will consist in the power possessed by this method of examination alone of revealing whether and to what extent any purification processes, natural or artificial, are able to remove disease-producing bacteria, should they at any time be present, from the water.

We do not intend to belittle the work of the bacteriologist. His services are valuable in studying natural waters and invaluable in determining the efficiency of filter plants which treat polluted water. Single analyses, of any kind, are of comparatively little use, while bacterial analyses of filtrates should not only be made frequently, but samples from each bed should be examined in order to determine whether each unit of a plant is doing its work properly. A fully equipped and well-manned bacterial laboratory is a desirable, if not necessary, adjunct of every filtration plant, and for certain waters a chemical and microscopical laboratory should also be in service. Where water is not purified, one or all of these laboratories can also be maintained to great advantage, but should be supplemental, in most cases, with frequent and searching sanitary inspections of the drainage area from which the water is derived. This latter work, as Prof. Wm. T. Sedgwick recently pointed out, would be a proper and profitable field for young engineering graduates.

THE POSITION OF UNITED STATES ASSISTANT ENGINEERS.

As most of our readers know, the work of the United States Government on its fortifications for coast defence and on the improvement of its navigable rivers and harbors is under the charge of the officers of the Corps of Engineers of the Army. This corps is made up of those graduates of the West Point Military Academy who stand highest in their classes at graduation; and while it might be thought that special aptitude in engineering studies might be a better basis of choice than the mere attainment of a high standard according to the West Point marking system, it must be confessed that the plan of selection has worked admirably in practice.

The total membership of the corps is now, we

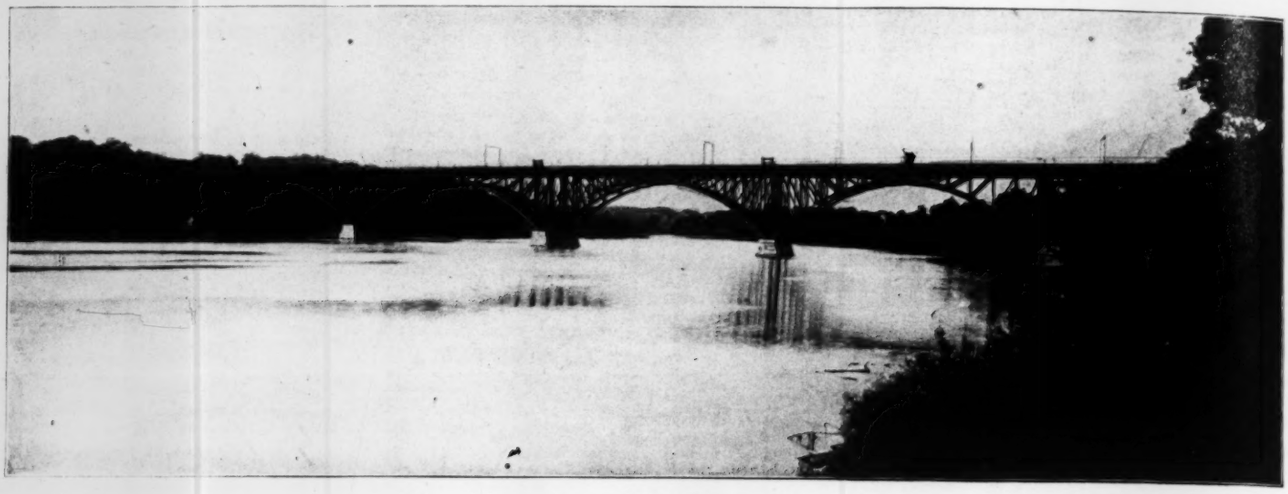


FIG. 1. GENERAL VIEW.

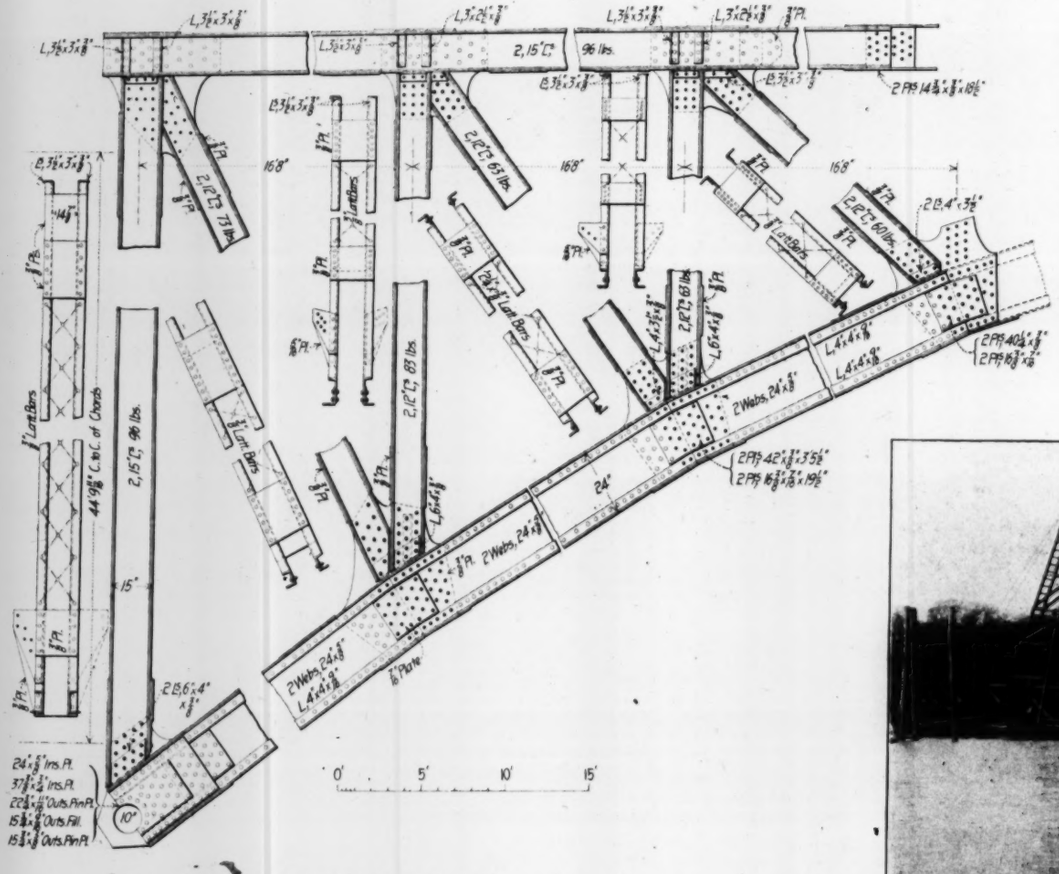


FIG. 5. END BEARING AND WEB DETAILS OF ARCH RIB.

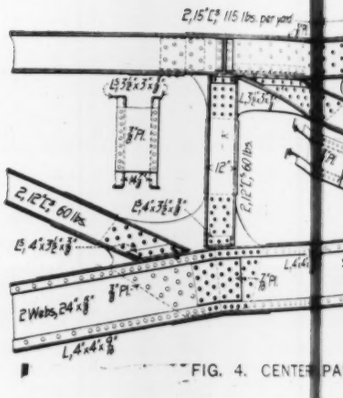


FIG. 4. CENTER PA

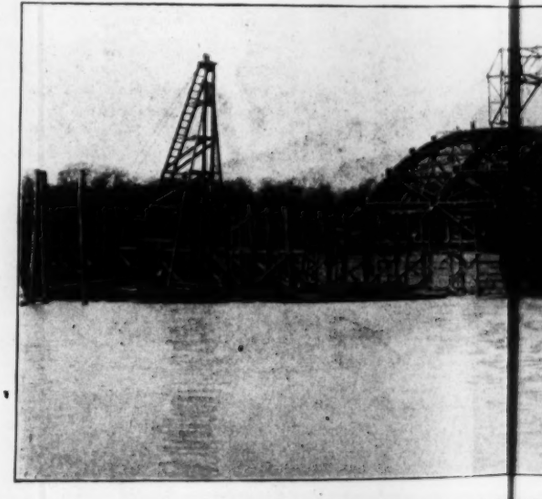


FIG. 6. VIEW SHOWING MANNER OF ERECT
BEFORE PLACING WE

STEEL ARCH BRIDGE OVER SCHUYLKILL RIVER,

Built by the Fairmount Park Transportation Co.

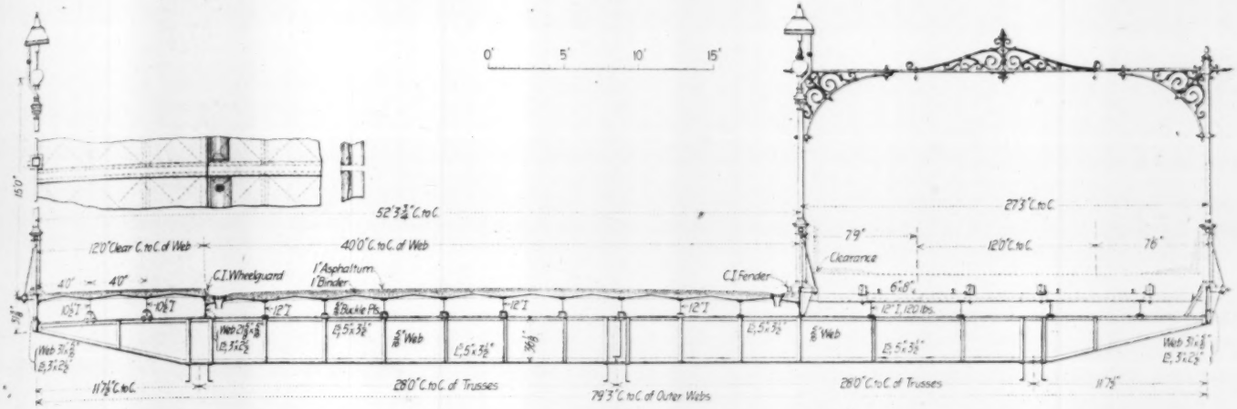
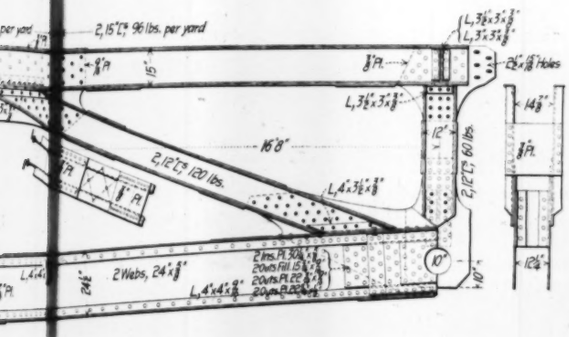


FIG. 2. TRANSVERSE SECTION SHOWING FLOOR CONSTRUCTION.



CENTER PANEL DETAILS FOR ARCH RIB.

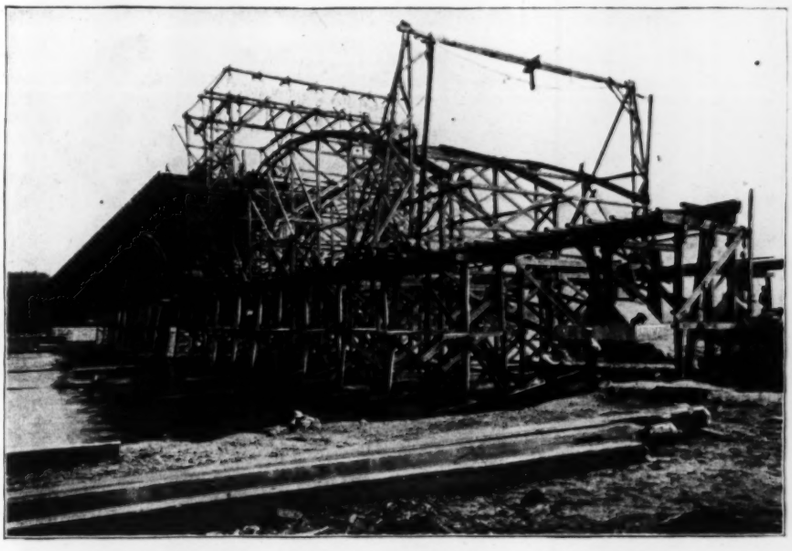
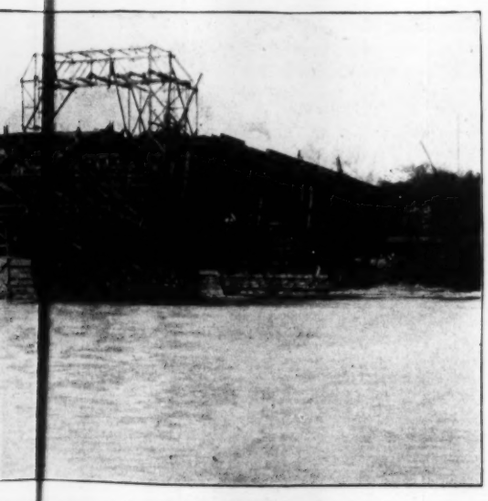


FIG. 7. VIEW SHOWING CONSTRUCTION OF FALSEWORKS. AND TRAVELERS.



OF ERECTING TOWER CHORDS COMPLETE
CING WEB SYSTEM.

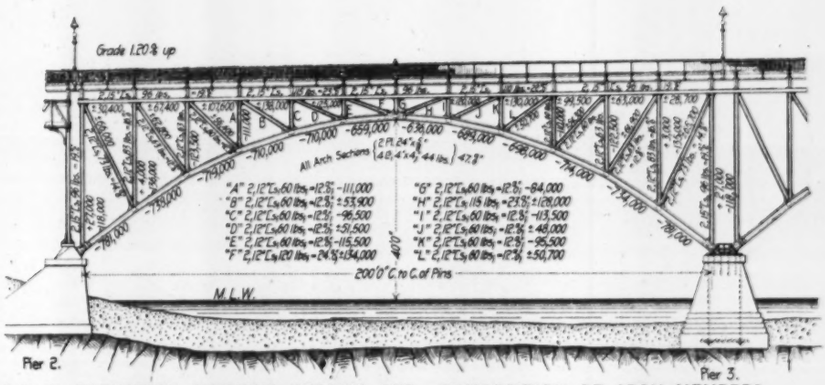


FIG. 3. ELEVATION SHOWING STRAINS AND COMPOSITION OF ARCH MEMBERS.

RIVER, FAIRMOUNT PARK, PHILADELPHIA, PA.

Designed and Erected by the Phœnix Bridge Co., Phœnixville, Pa.

believe, about 115; including the officers of every grade, and by a recent law it is to be increased to 127. It is manifest, however, that this number of engineers is wholly inadequate to perform the engineering work required in connection with the expenditure of the many million dollars which are laid out by the Government each year, on rivers, harbors and fortifications, and in carrying out other work such as that of the lighthouse board, which is entrusted to the Corps of Engineers. The officers in charge, therefore, have power to hire draftsmen, clerks, transitmen and various other assistants upon the works under their charge. Those entrusted with the most responsible work are given the title, U. S. Assistant Engineer. The number of such Assistant Engineers employed by the Government during the last fiscal year was about 180.

The subordinate title and inadequate pay of these assistant engineers have long been a source of serious complaint, and many years ago there was considerable agitation on the part of some of the local engineering societies in the West looking toward a reorganization of the system of conducting Government works. This agitation came to nothing, however, one reason being that the reforms proposed involved such radical changes as to arouse opposition, and the position of the United States Assistant Engineers remains what it has been for many years past.

The present time seems to us an opportune one to consider the position of these engineers and see what can and ought to be done to better it. It is by no means unlikely that the next half-dozen years may see the undertaking by the Government of public works of great magnitude, demanding for their most successful design and execution the highest grade of engineering ability. Engineers as a body must recognize the great desirability that the Government should secure such ability, and accord to those who furnish it such credit as they may deserve, and a monetary compensation that will serve as some standard in fixing the value of the highest class of engineering work in this country.

Under the present system we think every fair-minded man must concede that the Government falls far short of doing this. The pay of the 180 assistant engineers varies from $125 to $300 per month. They are hired and discharged as the work requires, and a large proportion of them are employed only a small part of the year. The highest salary named is paid to a very few of the men. We find only 68 with salaries of $200 or over, and only 13 with salaries of $250 or over. When the temporary character of the employment and the difficult and important nature of the work is considered, we contend that these salaries are inadequate in many cases for the high-class of professional ability that is needed.

It may be said that these engineers are not obliged to accept Government situations. If the compensation is inadequate, they can seek work in other fields; but such a comment betrays want of knowledge of the real state of affairs. A large proportion of these assistant engineers, if they are to perform the tasks assigned them as they ought, must devote years to study and practice in the special field of river and harbor engineering. The engineer who masters this science and becomes a thorough expert in this branch of the profession has absolutely no prospect of employment in this country except in the Government service; and the utmost that he can hope for in the Government service is employment of uncertain duration from month to month, at a compensation of at most $200 or $300 per month. Because an engineer accepts such pay does not prove that it is adequate. He may well prefer it to the alternative of seeking a subordinate position in some other branch of the profession, where his expert knowledge, so hardly acquired, would be of little or no value; but the fact that the Government has no competition in the employment of engineers on works for the improvement of navigation ought not to be taken advantage of to cut down their pay.

The fact is that when the temporary character of the employment is taken into account, there are, we believe, not a few clerks in the U. S. Engineer offices who are better paid, on the whole, than the assistant engineers. Indeed, for employees of the lower grades, such as clerks, stenographers, ordinary draftsmen, etc., the United States pays rather better wages than private employers, while its professional employees very generally receive much less.

Closely connected with the matter of rates of pay is the matter of title and position. No matter what ability a civilian engineer engaged on river and harbor work may possess; no matter how great a work he may design, his title is that of "Assistant Engineer," and his position is a subordinate one. The public so recognizes it; and until this is remedied, it will be of little use to agitate for an increased rate of payment. Members of Congress will say with truth that $200 to $300 per month is ample compensation for an "Assistant Engineer."

Various plans have been proposed for reorganizing our system of public works with a view to a more equitable treatment of the engineers employed upon them; but the great trouble with most of these plans has been that they involved changes altogether too radical. It has been proposed, for example, to take the control of these works entirely out of the hands of the officers of the Corps of Engineers. We are very sure that a strong protest would go up against any change of this sort, from whatever source it might come.

Among the officers of this corps are some of the ablest and most competent engineers that the country possesses. They are a set of picked men of thorough education and experience, and they have carried out the great works entrusted to their charge, involving the expenditure of hundreds of millions, with a faithful devotion to duty, a strict honesty, and an entire freedom from political intrigues, which are a lasting honor to them and to the profession to which they belong.

It may be said that if the officers of the Engineer Corps are able engineers, what is the need for engineers under them in other than subordinate positions? We will try to make clear why there is such a need. Out of a total number of officers in the Corps of Engineers, there are approximately 5 colonels, 12 lieutenant-colonels, 25 majors and 30 captains, or let us say in round numbers, about 75 men who are of sufficient age and experience to take responsible charge of large works.* The lieutenants and second lieutenants which form the remainder of the corps act as assistants to the officers of higher rank in the corps, instructors at West Point and Willet's Point, and in general occupy such positions as will fit them for places of greater responsibility at a later date. It will, of course, be understood that West Point cannot turn out full-fledged engineers any more than the civilian schools of engineering. In fact, the West Pointer at graduation may be less advanced than his civilian brother; for he has had to spend much of his four years' course on purely military studies.

These 75 men, more or less, have to supervise the expenditure of all the sums appropriated for river and harbor improvements, for the construction and repair of lighthouses, and for fortifications, a total of from $25,000,000 to $40,000,000 per annum. Besides this they have to report on a great variety of projected works, and on obstructions to navigable waters, to serve on boards and commissions, and as delegates to foreign countries,, military attaches, etc., to conduct the municipal engineering work of the city of Washington and supervise its public buildings and parks, and to perform various other incidental duties.

Another fact must be taken into consideration. Not every one of these seventy-five or more officers has sufficient engineering ability to handle efficiently large and difficult engineering problems. They have, it is true, professional training and experience; but in the making of a really great engineer we must always allow Nature some part. If one were to pick from the best civilian engineering schools, 75 students at their graduation, and attempt to make engineers of them all, it would be strange, indeed, if more than 50 per cent. proved to have ability enough to reach a Chief Engineership solely on their own merits. There is no reason why we should expect to find a greater proportion of prizes in selecting engineers from the graduating class at West Point; in fact there may be less reason, for the boy of 16 to 18 who starts for West Point seldom does so with the desire or expectation of becoming an engineer.

As a matter of fact, we find that the officers of the Corps of Engineers vary greatly in their professional ability. Many of them are indeed engineers of the highest rank. On the works carried out under their charge, when the demand on their time permits, they originate the design, take the responsibility of deciding all matters in which technical questions are involved, and are in actual fact the Chief Engineers of the work.

Another class of officers are frankly aware of their inability to handle intricate technical problems. They are the executive heads of the works under their charge; but all matters of a technical or professional character they turn over to their assistants. It must be said, too, that nearly all the officers of the corps are being compelled more and more to follow this course, no matter what their engineering abilities may be, through the multiplicity of the duties heaped upon them. There are, all told, but 24 hours in the day and 365 days in the year; and it needs but an examination of the amount of work which some of the engineer officers have laid upon them to realize that it is a physical impossibility that any one man can perform even a small part of the responsible engineering work which must be done in the course of a year.

The reform that we would advocate, therefore, is merely a frank recognition of the existing state of affairs. An officer in the Corps of Engineers is still the executive head of the works under his charge, and the people want him to continue the executive head; but he is no longer the Chief Engineer, and from the nature of things he seldom can be. The position he occupies and ought to occupy corresponds to that of the Commissioners in charge of large public works of states or cities, or the General Manager of a railway corporation. The laws and the regulations of his corps should be so amended as to recognize this, and also to provide for the employment of actual Chief Engineers on works of importance, exactly as the Commission in charge of building an important bridge, dam or aqueduct selects a Chief Engineer. It goes without saying that such a chief, entrusted with the responsibilities that would naturally attend such a position, would be entitled to a salary proportionate to his responsibilities.

But, it may be said, would not this increase the annual expense to the Government for engineering work? Probably it would, but the trifling amount which would be thus expended, would, we believe, be far more than offset by the saving that would be made in the total cost of the work done.

There are two tasks which ought to be performed by an engineer in the design of any engineering work. One, and the easiest one, is to make the work sound enough and stable enough to meet all demands upon it. Little more is required for this than to follow past precedents. The second and more difficult task is to see how the work can be built or made at the smallest expenditure; and it is here that a wide range of knowledge, inventive genius and familiarity with the latest improvements in materials and processes come chiefly into play.

An engineer who is crowded with work is often obliged to omit the second of these tasks. We doubt not many an officer of the Engineer Corps can call to mind work done under his direction, which he could have carried out at much less expense had he been given time to make all the needful preliminary studies.

We are not arguing, therefore, merely for an increase of salary to a class of engineers who amply deserve it. We are arguing for actual economy in the carrying out of our public works. Let the Government, instead of trying to see how little engineering work it can get along with in carrying out its river and harbor works, empower its engineer officers to employ such engineering talent as the importance of their work justifies, and see that their works are designed for economical as well as stable construction.

A word may now be given to some of the other

*The new law will increase to nearly 90 the total number of engineer officers of a rank above that of lieutenant; but the law cannot bestow upon the young lieutenants who will be promoted to fill these new positions experience and mature knowledge. That is a matter in which time is an essential factor.

schemes which have been proposed by those who have sought to benefit the assistant engineers. One proposition has been that the Government should adopt the Continental system of carrying on its public works, should place them under the control of civilians alone, and should create an established corps with life appointments, a regular system of grading and promotion, and pensions after retirement. No such scheme could have the ghost of a chance of adoption in this country. It would not only meet with intense public opposition, but it would make no provision whatever for varying the force to suit the work to be done. There is really no reason why the Government should not do as states, cities and private corporations do; engage professional services when the work in hand requires them, and dispense with them when they are no longer needed.

Again, it has been proposed that the Government should simply confine its engineer officers to purely military works and turn over to civil engineers all works of navigation improvement. Every friend of honest government would raise his voice against such a proposition as this. Experience, some of it very recent, has fully shown the danger of making professional appointments dependent on political pulls. The engineer officers now in charge of Government works hold life positions; they are dependent on no party boss for his backing, and their professional honor and integrity is everywhere conceded. To turn over their work to men who would probably depend upon congressional recommendation for their places, would be far from a benefit to the engineering profession.

Some assistant engineers have suggested that their position might be changed to correspond to that of the naval civil engineer corps, and they ask for a similar basis of relative rank, etc.; but they have a mistaken idea of the actual status of that corps. The Civil Engineer Corps of the U. S. Navy now contains only 15 officers, ranking from a Commodore, when Chief of Bureau, down to Lieutenants of the Junior grade. Excepting in numbers and in method of original appointment to the lower grades, this corps holds the same position in the Navy that the Engineer Corps holds in the Army; and, like the Engineer Corps, it also has full authority to temporarily employ civilian engineers when the needs of the service require it, and to discharge them when the demand has passed. It is true, that in the Navy, the original appointments are made from civil life; but their number is limited by law, and the pay is by no means high. They have a permanent position and a relative rank; but to apply the same methods to the admission of the U. S. Assistants into the Engineer Corps of the Army, would simply mean the permanent increase of the number of this corps to unnecessary limits.

We see no chance whatever that any of the three plans we have outlined and criticised can possibly be successful. On the other hand the moderate measure of reform which we have proposed is, we believe, entirely practicable, and might be brought about if the profession at large were to take hold of it. The assistant engineers themselves can do little; for agitation on their part will be set down to mere desire for greater perquisites. The officers of the Corps of Engineers can hardly take a prominent part in such a reform, without transgressing the rules that govern their corps. It rests with the engineering profession at large, through its organized bodies, to take up the matter and urge it to a solution.

A great deal is being said concerning the need for a higher standing for the engineering profession, and various large schemes are being discussed to better it. It seems to us wise to undertake the smaller tasks first. If the engineering profession can bring about a just recognition and compensation for the civilian engineers employed in responsible positions on the Government's great works of river and harbor improvement, it will do a great deal to raise and dignify the standing of the profession in the eyes of the public.

LETTERS TO THE EDITOR.

The Paints on the 155th St. Viaduct, New York City

Sir: I desire to offer some criticisms upon the tests of the paints used upon the 155th St. viaduct, New York, as presented by Mr. Henry B. Seaman, in your issue of July 17.

It is very unfortunate that under "kind of paint" he does not state what each paint is composed of. If he had so stated, one could judge better of the value of the pigment part of the paints.

Acording to the list, Nos. 2, 4, 13 and 14 are practically the same, although they represent the product of different manufacturers, and without doubt each has a different percentage of graphite in the pigment. Any one purchasing graphite paint under such a title does not know how much silica or clay or other things and how little or how much pure graphite there may be in it.

No. 1 does not state whether red or white lead was used, and if the result turns out as suggested in the memorandum marked 1, notwithstanding its large percentage of freedom from rust, it has proven itself to be no good for further protection and should be condemned.

One must not suppose that No. 3 means straight red lead and linseed oil, although that impression will prevail to a great extent. It is doubtful if there is much or any of this pigment in this paint marked "antoxide," which is a trade name of the manufacturer for this particular paint. Absolutely pure red lead and linseed oil makes a better record in such tests.

No. 5, the paint showing the largest percentage, was used with three coats, which gives a decided advantage over a paint which has only two coats used, and probably the proportion of durability would be as 3 to 2. Therefore, No. 12 with two coats only would, it is safe to assume, show up with three coats equally as well as or better than No. 5 "Nobrac" (which is carbon spelled backwards and is a trade name), if placed in the same position where it caught the direct effect of the sulphur fumes from the locomotives.

The result of these tests as they appear in your issue of July 7 will be very misleading to the average reader. In order to make a report complete and valuable, a knowledge of the constituent parts of the paint is essential; and if any salesman or agent or manufacturer refuses to give that when demanded, his paint should not be countenanced for a moment. Respectfully, W. B. Parker.

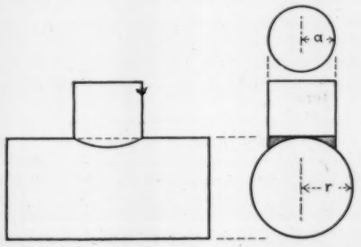
Chicago, Ill., July 11, 1898.

(Mr. Seaman's report was criticised in some other respects in our issue of July 21.—Ed.)

A Problem in Solid Geometry.

Sir: You will favor me greatly by publishing a formula (with its derivation) for the volume included between two cylinders of different diameters whose axes intersect at right angles.

The problem comes up in computing the contents of a



railroad tank car when it is filled up into the dome or small cylinder. Yours very truly,

Alex. N. Miller.

East End Gas Works, Cincinnati, O., July 23, 1898.

(The best practical solution of this problem would be to fill the tank with water and weigh or measure it. To obtain a formula to fit the general case is a very interesting and by no means easy problem in integral calculus whose solution ought to be given in the books on that subject; but we have not been able to find it in five different works that are at hand. We refer it to any of our readers who like to wrestle with mathematical puzzles in August.—Ed.)

Power of Windmills.

Sir: There having lately come under my notice, in the Kansas University "Quarterly" for April of last year, an article by Mr. Murphy,* in which he gives the results of a number of tests made by him for the determination of the power developed by wind-engines; and as these tests were carefully made on wheels of a number of different makes and on wheels of different sizes of the same make, all under regular service conditions as they performed their every-day work, and cannot but be of real value, I thought that a comparison of these results of actual practice with the results obtained by the simple little formula which I sent you some two** or three years ago might prove of interest to some of your readers, as it shows that this formula is a sufficient guide for the determination of the size of wheel required for any given amount of work.

The formula which I then proposed was

$$HP. = .0001\ D^3,$$

where HP. is the net horse power developed with an air current of 16 miles per hour, and D is the diameter of the wheel in feet.

From Table I. of the article above referred to, after throwing out the results obtained from the tests on the "Jumbo" and the "Fairbanks" wheels, as these results show only one-tenth the power which wheels of their size should develop, and those of the "Ideal," which are not at all consistent one with another (the 14-ft. wheel giving only about one-third the power of the 12-ft. wheel and one 8-ft. wheel giving three times the power of the other), and arranging the remaining results in the order of the size of the wheels, we form the first four columns of the following table. The fifth column is the average for each size wheel of the values given in the fourth column, and the sixth column gives the horse power for each size wheel as given by the formula HP. = .0001 D³.

Mill number.	Name of Wind-Engine.	Diam. in ft.	Actual horse power with wind blowing 16 miles per hour.	Aver. horse power of wheels of same diam.	Horse power as given by HP. = .0001 D³.
9	Aermotor	16	0.433	0.433	0.410
3	Aermotor	12	0.207	....	....
7	Aermotor	12	0.221	....	....
2	Mogul	12	0.260	....	....
13	Aermotor	12	0.171	0.184	0.173
17	Gem	12	0.149	....	....
19	Gem	12	0.162	....	....
21	Halliday	12	0.121	....	....
15	Gem	10	0.082	....	....
16	Halliday	10	0.103	0.093	0.100
5	Aermotor	8	0.072	....	....
6	Gem	8	0.042	0.057	0.051

From this table it will be seen how close the results given by the formula agree with the average results obtained in practice.

In case one is dealing with a strictly high-class wheel, as the Aermoter, it would be better to add another term to the formula, making it

$$HP. = .002\ D + .0001\ D^3.$$

Taking mills Nos. 9, 3, 7, 13 and 5, all Aermoters, from the table above given, we would have:

Diameter of wheel in ft.	Average HP. from tests.	HP. from formula, HP. = .002 D + .0001 D³.
16	0.433	0.442
12	0.200	0.197
8	0.072	0.067

or, in round numbers,

16	0.43	0.44
12	0.20	0.20
8	0.07	0.07

which leaves little to be desired.

Respectfully yours, M. Fargusson.

Southport, N. C., July 22, 1898.

The Moduli of Elasticity of Cast Iron.

Sir: Can you give me, or, if not, where could I obtain, reliable information, based upon tests, by which to determine the modulii of elasticity of average American cast iron for compression and for tension? Many text-books of engineering state that in cast-iron beams under transverse strain, loaded in the usual manner, the neutral axis is situated some distance above the center of gravity of the section, owing to the difference between the compressive and tensile strength of the material; however, they give only one modulus of elasticity. Now, it can easily be proven, theoretically, that the position of the neutral axis is dependent upon the two modulii of elasticity and their difference, and is entirely independent of the ultimate compressive or tensile strength of the material.

Aside from a scientific standpoint, this question may be of interest to engineers, although cast iron is now so little used to resist transverse strain. In many cases, however, reliable formulae for calculating the resistance of irregular cast-iron sections would be useful; e. g., for columns eccentrically loaded, bases, brackets, etc. Similar reasoning is applicable to stone or concrete sections, as, e. g., footings. Very respectfully, F. Carl Polimar.

Newberry Building, Detroit, Mich., July 19, 1898.

(Wood's "Resistance of Materials" gives a record of a tensile test of American cast iron made by Capt. Rodman, in 1857, which shows that the modulus of elasticity decreased from 27,000,000 at 3,000 lbs. per sq. in. to 18,000,000 at 14,000 lbs., and to 10,000,000 at 24,000 lbs. In Kent's "Mechanical Engineers' Pocket Book," p. 314, there is given the record of another test showing a decrease of the modulus from 25,000,000 at 1,000 lbs. per sq. in. to 12,500,000 at 8,000 lbs., the piece breaking at 23,285 lbs. per sq. in. Wood gives the record of a compression test made by Rodman, of

*Mr. Murphy's experiments were described in our issue of Aug. 19, 1897.—Ed.

**Eng. News, Nov. 14, 1895.

a cylinder 10 ins. long, in which the modulus increased from 11,000,000 to 14,500,000, with an increase of the stress from 1,000 to 15,000 lbs. per sq. in., while a test by Hodgkinson on a bar 10 ft. long showed a decrease in the modulus from 13,000,000 to 11,000,000 for an increase in the stress from 2,000 to 33,000 lbs. per sq. in. The modulus of elasticity of cast iron appears to be extremely irregular, both in tension and in compression, depending, no doubt, upon the quality of the iron, but in tension it always decreases shortly after the beginning of the test, showing no definite elastic limit. Johnson's "Materials of Construction" says the modulus of elasticity in cast iron varies from 10,000,000 to 30,000,000, and that it is approximately the same in tension, in compression, and in cross-bending. Any attempt to construct a formula for strength of cast iron on the basis of its moduli of elasticity in tension and compression, we think, would be a waste of time. Concerning formulas for strength of cast-iron columns and brackets, see Engineering News of Jan. 13 and 20 and June 30, 1898.—Ed.)

MASSACHUSETTS EXPERIMENTS ON THE PURIFICATION OF FRESH, STALE AND SEPTIC SEWAGE.

By H. W. Clark.*

For the past ten years, systematic investigations in regard to methods of sewage purification have been carried on by the State Board of Health, of Massachusetts, at the Lawrence Experiment Station, which was established largely for that purpose. Many of these investigations can be properly classed under the head of experiments upon purification by intermittent filtration, and many modifications of intermittent filtration have been studied. Moreover, all these studies have been carried on, not with the idea of obtaining results only, but of making clear the essential principles by which the purification of sewage can be effected. It seems to be an opportune time to say this, and to present a brief review of a portion of the work of the station during its first eight or nine years of operation, and also of the results of some investigations recently made, on account of the considerable quantity of literature recently published in regard to the results obtained by the so-called septic tank system and bacterial filters of England.

Papers, dealing with the septic tank and bacterial filter methods, have been presented, once or twice recently, to engineering and chemical societies by American engineers and chemists, as something entirely new in sewage purification, apparently overlooking a large amount of data published in the reports of the Board, bearing upon the principles of these methods; that is, the chemical and bacterial actions by which purification is effected by them.

Sewage, as ordinarily understood, is that volume of filth flowing in our sewers, consisting of the wastes from houses, stores and in some cases, streets, together with the water used in washing these wastes into the sewers; sometimes this volume of sewage is largely augmented by the addition of waste liquors from manufacturing industries.

Let us consider, for a moment, the composition of domestic sewage; that is, sewage free or almost free from manufacturing wastes. It is evident that, with a given population, the strength of the sewage produced, or, in other words, the degree of pollution of the water flowing in the sewers varies inversely as the volume of water used by that population. It is generally much more dilute in American than in European cities and towns, owing largely to the extravagant water consumption of the average American municipality. It is a difficult matter to state what is a representative sewage, but, taking the Massachusetts cities and towns from which the State Board of Health obtains samples of sewage for analysis, the average sewage of these towns and cities analyzes about as follows, in parts per 100,000:

Total solids, 45 parts; loss on ignition, 20 parts; free ammonia, 2 parts; albuminoid ammonia, 0.55 of a part; chlorine, 5.5 parts; oxygen consumed from permanganate, 3 parts.

Of course, during a portion of the 24 hours in almost any of these cities and towns, a sewage is flowing much stronger than that indicated by this average, but in all of them a considerable amount of ground water enters the sewers at all times of the day, and during the night the sewage is much weaker than during the day-time, being in some places largely this ground water.

In 1888 the Lawrence sewage pumped at the Experiment Station contained 1.55 parts of free ammonia, and 0.69 of a part albuminoid ammonia, making its total nitrogen contents 2.4 parts. During 1897, however, the average free ammonia in the sewage pumped was 4 parts, and the average albuminoid ammonia 0.83 of a part, making the total nitrogen contents 4.62 parts; an increase of about 95% in the amount of unoxidized nitrogen present in the sewage. Now, while the strength of the sewage pumped at the Station had doubled, its composition in regard to the arrangement of its nitrogen and carbon contents had also changed very materially; and in regard to this change in composition, which has been many times referred to in the reports, I wish to present a few facts.

It is evident that, when the mixture of water and organic matters of all kinds, such as are found in sewage, has just occurred, and little chance or time has been given for mechanical, chemical and bacterial actions to take place, we must have a liquid flowing in the sewers containing organic matter quite different in its general composition from the same matter in this liquid after opportunity and time have been given for these various actions. The fresh sewage, that is, the sewage just as it enters the sewers from houses or streets, contains free oxygen and generally nitrates and nitrites. As it flows along the sewer, the organic matters are decomposed in the presence of this free oxygen and the oxygen of the nitrates and nitrites, largely by the bacteria present, and the composition of these organic matters is radically altered by these actions, the crude matters being changed to simpler forms, probably in the following way:

The bacteria first attack the carbon, and, in the presence of free oxygen, convert it to carbon dioxide; the nitrogen and hydrogen set free unite to form ammonia, and this joins with the carbon dioxide, forming ammonium carbonate; thus, the free ammonia, so-called, of the sewage increases quite rapidly for a time, while the crude, organic matters decrease. For instance, analyses of samples of sewage from different localities in the State of Massachusetts show the following results upon this point; these analyses having been presented in the reports of the Board for 1894 and 1895:

Samples collected at the Worcester Lunatic Hospital, from the sewer at a point a few hundred feet from the buildings, and a few minutes after the mixture of water and organic bodies has taken place, show only 17% of the total nitrogen of the sewage to be present in the form of free ammonia. Samples from Marlborough, collected at a point, to reach which all the sewage must flow at least four miles, show 56% of the nitrogen present to be in the form of free ammonia. Samples from Framingham, taken at a point, to reach which all the sewage must flow about two miles, show 49% of the nitrogen present to be in the form of free ammonia. Samples taken from a manhole in the Lawrence St. sewer at Lawrence show from 30 to 36% of the nitrogen present in this sewer to be in the form of free ammonia; and samples of practically the same sewage, collected at the Experiment Station, after it had been 24 hours longer on its journey from a point near this manhole through the pipe to the Station, show about 60% of the nitrogen present to be in the form of free ammonia. Reversing these figures, it will be seen that the fresh sewage, taken directly from the Lawrence St. sewer, has about 60% of its nitrogen present in the form of crude organic nitrogen; while the stale sewage, collected at the Experiment Station, has on an average about 40% of its total nitrogen in the organic form.

Investigations in regard to this change have been made at the Station, and published in the reports of the State Board of Health from time to time. For example, upon p. 461 of the report for 1894, the following experiment is given:

A gallon bottle was filled with fresh sewage taken directly from the manhole in the Lawrence St. sewer previously mentioned, and analyzed as soon as possible after collection. Subsequent analyses were made every two or three hours during the first two days of the bottle's standing in the laboratory, and once a day thereafter for a period of six days. The results showed that, upon standing 24 hours, the free ammonia increased about 100%, and the dissolved oxygen and nitrates and nitrites disappeared; the dissolved oxygen being present at the time of collection in an amount equal to about 57% of that necessary for saturation of water at the temperature of this sample of sewage when collected. The total organic nitrogen decreased 50% within 24 hours, and 67% during the entire experiment. The insoluble organic nitrogen decreased about 60% during the first 24 hours, and 80% during the entire experiment. The amount of oxygen consumed from permanganate decreased 50% during the entire experiment, caused by the formation of carbon dioxide. This bottle of sewage stood upon the table in the laboratory, and so was exposed to light, and frequent removal of the stopper allowed the access of air; therefore, it was not under the same conditions as the sewage held in the septic tank at Exeter, England. On the other hand, the bottle was shaken each time before a sample was taken from it for analysis, thus getting an amount of sludge proportionate to the volume of sewage taken for analysis; whereas, the sewage from the septic tank is drawn from a point midway on this tank, and only a small amount of sludge is obtained with a sample of the tank effluent. This experiment and its results were spoken of in the report for 1894, as an illustration of the initial step in the purification of organic matter by bacterial action.

In a discussion of the composition of sewage and the permanency of filters in the report of the Board for 1895, it was stated that, if the sewage is stale when reaching the place of disposal, the organic matter in suspension is finely divided by the comparatively long continued mechanical, chemical and bacterial actions through which it has passed, and a much larger percentage of the organic matter will readily pass into the interstices of the filtering material than will be the case with fresh sewage, and that the surface of filters will not become clogged by the crude organic matters of the sewage so readily as they will when fresh sewage is being applied. Also, it was stated that the organic matter in the stale sewage has apparently been worked over to such an extent during its slow passage through the pipe from the sewer to the Station, that not only has it lost a certain proportion of its sludge, but the remainder is of a nature more easily attacked by the bacteria in the filter than is the fresh organic matter. These statements and the investigations giving rise to them were made because it was evident that the experimental filters in operation at the Station, while receiving with the sewage applied to them a greater amount of organic matter than during earlier years, were producing better results than was the case two or three years previous to this, and also were not storing much of the matter applied.

To demonstrate further the better work of a filter receiving stale sewage than one receiving fresh sewage, an experiment was made in 1896, and published in the report of the Board for that year; two small filters being started, one receiving the stale sewage pumped at the Station, and the other, fresh sewage collected from a manhole in the Lawrence Street sewer. The total nitrogen in the fresh sewage was 4.35, and in the stale sewage, 4.23 parts per 100,000. Only 27% of the nitrogen in the stale sewage was organic nitrogen, the rest being in the form of free ammonia, while the fresh sewage contained 60% of its total nitrogen contents in the organic form, the remainder, or 40%, being in the form of free ammonia. The oxygen consumed from permanganate by the fresh sewage was about 2½ times that consumed by the stale sewage. After six months' operation of these filters, the one which received

*Chemist of the State Board of Health of Massachusetts, Department of Water Supply and Sewerage, Lawrence, Mass.

the fresh sewage had stored 26% of the applied nitrogen, while the one receiving stale sewage had stored but 12%, this latter filter being operated without disturbance of its surface, while, owing to the crude sludge applied with the fresh sewage, the surface of the filter receiving it had to be raked several times during the period of operation.

On account of these and other investigations at the Station, we have long known that the volume of sewage which a given area of filter bed will successfully care for and render pure varies not only according to the strength of the sewage applied, but also according to the composition of the sewage, as I have explained it; that is, the arrangement of its carbon and nitrogen contents, whether in the soluble or insoluble form. Such sewage as that collected from the sewer of the Worcester State Lunatic Hospital contains comparatively little organic matter in solution, and the organic matter in suspension is not finely divided; it is, therefore, evident that when such sewage is applied to a filter, there will be strained out and left upon the surface of this filter a large amount of crude organic matter to be slowly acted upon by the air and bacteria; that is, if the sewage runs directly to this area. If, however, it passes through properly arranged screens and sedimentation basins, a large proportion of this crude insoluble matter can be removed from it before it passes to this filter. Then we have to purify by filtration a body of liquid containing perhaps only a small proportion of its original organic pollution; but we shall also have a large body of sludge, so-called, to be in some way disposed of.

On the other hand, a sewage similar to that now and for several years past pumped at the Lawrence Experiment Station, or pumped to the beds at Marlborough, can be called in distinction from the fresh Asylum sewage, a stale sewage; that is, one in which the crude organic matter has been worked over by chemical and bacterial actions, resulting not only in a change of the form in which this matter is present, but also in the loss of a portion of the primary amount, this loss occurring as has been explained.

To purify sewage, we separate from a large volume of liquid the relatively small amounts of organic and mineral matters contained in this liquid.

Intermittent filtration is a bacterial and oxidizing process of purification by means of which the organic matter present in the sewage is removed, both by change into gaseous forms and escape into the air, and change to the inorganic form, and passing away as harmless mineral salts in solution in the effluent of the filter. We have seen how the organic matter, by a process of decomposition, that is, by the action of a certain class of bacteria working in the presence of oxygen, is gradually changed to free ammonia. It is this free ammonia that the nitrifying and oxidizing bacteria present in the filter change to nitric acid, which joins with some such base as potassium or sodium present in the sewage, to form nitrates which, as stated, come through in solution in the effluent. This action is the main one upon which the purification of sewage by intermittent filtration depends, and all care of an intermittent filter is a constant aim to so handle it that everything will be favorable for this action to take place and continue vigorous.

We have seen the different form in which the carbon and nitrogen present in the sewage may reach the filter's surface, according as the sewage to be disposed of is fresh or stale, and it is evident that the amount of work to be done in the filters by the bacteria present varies greatly, owing to this fact. That is, if the sewage is as fresh as the Worcester Asylum sewage, a much larger amount of work and a greater change in organic matter has to be accomplished in the filter before the sewage is purified than has to be done if stale sewage, which has been long enough in the sewer for the beginning of the bacterial actions to take place, is applied to the filter.

The question now being agitated is whether the breaking up of the organic matters cannot be better effected by holding the sewage in a tank without access of air, and thus aid the growth of that class of bacteria which can live without air, than with free access of air and action on the filter's surface, and within the filter by the bacteria acting in the presence of air.

I will present here a few examples of what can be accomplished by the filtration of sewage without preliminary forced putrefaction. For periods varying from eight to ten years, we have had in operation at the Station seven large experimental filters, 1-200 of an acre in area, and containing sands or gravelly soils common to New England. These filters have been operated at rates of from 20,000 to 120,000 gallons per acre daily, and daily analyses made of the sewage applied to the filters and the effluents from them. We have also kept watch of the condition of the filtering material, in order to learn definite facts in regard to the storage of organic matter in this material, as the maintenance of an equilibrium between the organic matter applied to the filter and that lost by being nitrified and changed to the inorganic form, or passing away into air in the form of carbon or nitrogen gases, is necessary, in order to insure the permanency of a filter; that is, the permanency of the whole depth of the filter body, not making allowance for any removal of clogged sand from the filter's surface.

It is a fact that there was, for some years after the filters were started, an increasing accumulation of sludge or organic matter stored in these filters. The reason for this is not, perhaps, entirely clear. Fresh sewage, so-called, was being applied during the first years of operation, instead of the stale sewage subsequently applied; but the stale sewage contains more sludge than the fresh sewage did, owing to the increased strength of all the sewage flowing in the sewer and pumped to the Station. On the other hand, we have taken better care of the upper portion of each filter bed for the past five or six years; that is, the surface of each filter has, during these years, been disturbed by occasional raking, and has been spaded over to a depth of 6 ins. each spring and fall. One of the filters, however, when clogging began, had been treated in this way with apparently little effect in aiding the removal of the stored organic matter, or in producing better filtration results.

It seems probable, taking everything into consideration, that, besides the improvement of all the filters of late years, caused by increased care of the upper portion of them, the stored organic matter was, during the clogging period, being slowly worked over by the millions of bacteria present, until, finally, small portions of it arrived at a condition in which it was easily attacked by the nitrifying and other bacteria present in the filter, and with the usual results. When this time was reached, each daily addition of indigestible matter, which had to remain in the filter and be worked over for a long period, was offset by the daily amount which had been worked over for this long period and was being removed as nitrates in the effluent.

Analyses of the sand during this period of clogging showed the presence of a large amount of fatty matters. Now, however, although the sewage applied contains fully as much fat as was present during the first years of operation, it does not seem to accumulate in the filters. Whether we have cultivated in the filters a species of bacteria now capable of disposing of this fat readily, or whether the more prolonged actions of the bacteria in the sewer and sewer pipes, caused by the longer stay of the sewage in these places, have broken the fats and fatty matters into simpler forms, more easily handled by the bacteria present in the filter, we cannot state. The latter theory seems the more probable one.

It is worth mentioning here that we have in one of the towns of the state two experimental filters in operation, receiving tannery sewage containing a very large amount of fat. Tannery sewage is, of course, of considerable age and in an advanced state of putrefaction when allowed to run to waste from the tannery, and the fatty matters present do not clog the filters, but pass through into the effluent.

Quoting from our reports, I have given experiments showing the change in the composition of sewage with increased age; showing also the loss of crude organic matter taking place as sewage grows older; and showing the greater ease with which intermittent sand filters can dispose of stale sewage than fresh sewage. These facts are now being taken advantage of by the so-called septic tank system, first in operation in Exeter, England. This is an air-tight tank into which the sewage passes, and is retained for a time in order to allow the bacteria of decomposition and putrefaction to break up the organic matters into simpler forms, and thus reduce the insoluble matter, or sludge, by causing a considerable portion of the carbon and nitrogen to be so changed that it is either in solution in the sewage, or will pass away from it in the form of gas. As I have said, I have given data showing that the actions by which this process is made successful have been thoroughly understood by us for a considerable time, and the fact that sewage would lose a certain percentage of crude organic matter when held in a body has certainly been known. Anyone who has ever had any experience with, or noted the changes taking place in an ordinary cesspool, must have had their attention drawn to this fact. We had not, however, ever considered that these actions could be utilized as now proposed by the septic tank system.

We have, however, studied the method to some extent during the past few months with very interesting results. The sewage remains in our tank 24 to 36 hours, and is drawn from a faucet midway between the top and bottom of the side of the tank, as at Exeter. Thus we avoid drawing out the sediment from the bottom of the tank, and the fat and fatty matters which accumulate upon the surface of the sewage. The sewage, after its stay in the tank, is, when drawn from it, of an exceedingly offensive odor, quite highly colored, but clear for sewage, and containing a relatively small amount of matters in suspension. The free ammonia has increased slightly, and the total albuminoid ammonia has decreased about 50%, and the organic matters indicated by the determination of oxygen consumed from permanganate also about 50 per cent. Of course, no nitrification takes place within the tank, and we have found that all the nitrifying and oxidizing bacteria, that is, those bacteria depending upon the presence of oxygen for their life and functional activities, are destroyed while the sewage is passing through the tank. When entering, the sewage contains nearly 4,000,000 bacteria per cu. cm., and when drawn out about 250,000 bacteria per cu. cm., a reduction of 95%.

The following analyses show (1) the composition of the fresh sewage taken from the manhole at the Lawrence St. sewer; (2) the composition of the stale sewage as it is pumped at the Station, which enters the septic tank; and (3) the composition of the sewage drawn from this septic tank:

(Parts per 100,000.)

	Ammonia—Free.	Ammonia—Alb.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen consumed.	Bacteria, per cu. cm.
From sewer	2.60	1.18	0.10	0.0210	8.50	1,950,000
Station sewage..	4.50	1.05	0.00	0.0000	4.80	3,800,000
Septic sewage ..	5.50	0.55	0.00	0.0000	2.50	250,000

We see by the three analyses the following changes: A regular decrease in the albuminoid ammonia, with the necessary increase in the free ammonia resulting from this, and a regular decrease in the amount of oxygen consumed from permanganate. The sewage taken from the manhole at the sewer has little odor, and that not at all offensive. As pumped at the Station, the odor is only slightly increased; but as drawn from the septic tank, the odor is very offensive; that is to say, we have had changes, produced by the bacteria working upon the organic matter present, something as follows:

These organic bodies are compounds of carbon, hydrogen, nitrogen and oxygen. The first action is the formation of carbon dioxide, free ammonia —which joins with this carbon dioxide—water, and probably nitrous oxide. The next action which takes place in the septic tank is the further breaking up of these bodies, without the presence of free oxygen, and the formation of ill-smelling gases; that is, the organic matter has been well broken up and is well on the way to its reduction—if I may call it so—to its lowest terms by the bacteria acting during the time in which the sewage has been held in a body.

The septic sewage is applied to two filters, one an ordinary intermittent filter containing 5 ft. in depth of sand of an effective size of 0.23 mm., a sand very favorable for effective and satisfactory purification by intermittent filtration. The rate of operation of this first filter up to the present time has been 100,000 gallons per acre daily. Nitrification was very slow in starting in this filter, much slower than would have been the case with a filter receiving sewage in a less advanced state of putrefaction, and containing the large number of bacteria present in the sewage as it is pumped to the Station, and before entering the septic tank. Even at the present time, after four months' operation, although nitrification is quite active within this filter, averaging about 2½ parts nitrates in the effluent during the past few weeks, still the effluent is very turbid and ill-smelling. If the ordinary sewage pumped at the Station had been applied at an equal rate during these four months of operation, we should certainly be obtaining an effluent at the present time, clear, practically colorless, with little turbidity and no odor.

The reason for the comparatively poor result obtained so far by the intermittent filtration of this septic sewage is undoubtedly due to a number of facts, the principal one being that, although the nitrifying bacteria have finally become established within the filter, yet each application of sewage, passing down through the filter, has set free from it the gases generated in the septic tank and retained in solution in the sewage until this time, these gases being inimical to the life of the bacteria in the filter, which are of an entirely different class from those growing in the septic tank. The gases also rapidly exhaust the air in the filter; the filter effluent containing no dissolved oxygen in distinction from the effluent from filters receiving ordinary sewage. It can be said also that, while the filter shows no signs of clogging, and the sewage disappears quite readily from its surface, still the turbidity and disagreeable odor of the effluent seem to be increasing at the present time, rather than decreasing.

The second filter receiving this septic sewage is a bacterial filter, so-called, containing 5 ft. in depth of small pieces of coke. Before describing the action of this filter, I wish to make a few statements in regard to bacterial filters. Of course, all properly constructed filters are bacterial filters. Lately, however, this name has been given to a class constructed and operated in a somewhat novel way. The first bacterial filter in operation at Lawrence was started early in 1894, and contained 5 ft. in depth of gravel. Since then, others have been started, of cinders, coke, etc. The method of operation and the reason for naming them as they have been is as follows:

They are all filters of comparatively coarse material, having a large percentage of open space, and the sewage is applied in such quantity that this entire open space is filled daily, or even several times daily, the idea being that, as the sewage is drawn off, this open space becomes filled again with air, and hence the organisms work through the entire depth of the filter, instead of working in the upper layers only.

A bacterial filter receiving septic sewage was put in operation nearly four months ago at a rate of 800,000 gallons per acre daily. At this rate the sewage passing through it has had removed from it a very large percentage of its organic matter. No nitrifaction, however, has started within this filter, and reasoning from previous results it would seem probable that a considerable percentage of the organic matter removed from the sewage by the filter is being stored within it at the present time. I say, this seems probable, reasoning from results obtained with fresher sewage. It may not be so, however. We have found that in intermittent filtration fully 30%, on an average, of the nitrogen in the applied sewage escapes into the air in the gaseous form, and it is very possible that a much greater percentage is lost in this manner from the bacterial filter receiving septic sewage with its organic matter well on the way towards its reduction to its lowest terms, as has been explained.

We have, moreover, in this filter evidently a class of bacteria which carry on the purifying action begun in the septic tank still further, even although the nitrifying organism is not present, and as a result the effluent of the filter, although containing a large amount of free ammonia and an amount of albuminoid ammonia considerably above the average amount usually present in the effluents of our intermittent filters receiving ordinary sewage, is odorless and remains so indefinitely, and is only slightly turbid: That is, the ill-smelling hydrogen gases have either been destroyed or have passed away from the sewage during its stay in the filter, and the organic matter remaining in the effluent has apparently reached a state where no further putrefying actions can take place. This effluent is of a very good appearance as far as color and turbidity are concerned, being much better in this respect than the effluent of the intermittent sand filter receiving septic sewage and operating at only one-eighth the rate of this bacterial filter. Analyses of these effluents are as follows:

(Parts per 100,000.)

	Ammonia. Free.	Alb.	Ni-trates.	Ni-trites.	Oxygen con-sumed.	Bacteria, per cu. cm.
Effluent of bacterial filter	4.30	0.17	0.00	0.0025	0.75	55,000
Effluent of intermittent filter.	1.75	0.13	2.60	0.2600	1.08	140,000

The aerated gravel filters described in our Reports also gave an end result in regard to producing an odorless effluent similar to this. On p. 469 of the report of 1895, the following statement was made:

Comparing the resulting liquids after the treatment of sewage by various methods of removing sludge, it is noticeable that the organic matter in the liquids, after rapid filtration combined with aeration, is of a different character from the organic matter in the sewage resulting from the other sludge removing processes; that is to say, even when the organic matter as shown by the albuminoid ammonia is present in these effluents in as great quantities as in sewage after chemical precipitation or straining through coke, it has passed through such chemical and biological changes that it develops offensive odors very slowly on standing.

Bacterial investigations are, of course, being made, and the organisms so far isolated from the effluent of the septic tank show greater development at a temperature of 65° F. than at either a lower or a higher temperature.

In conclusion, it can be said that the septic tank process is one of much interest to anyone studying sewage purification, but there are two drawbacks: First, the fact that a large body of septic sewage must be exceedingly offensive and cause a nuisance where the same volume of fresher sewage would not cause a nuisance; and second, the construction of a reservoir of sufficient storage capacity to hold a large volume of sewage—that is, one day's flow from a municipality of average size—would be quite an expense. It seems probable to me, however, that a much smaller tank can be used in proportion to the volume of sewage flowing than is used at Exeter, and for this reason: A sewage of ordinary age, that is, one which has traveled for any great distance in the sewers, will, when it reaches its point of disposal, be practically free from dissolved oxygen, all having been used up by the bacteria and organic matter before reaching this point. Now, if such sewage runs into a properly built septic tank, no air will be carried in with it, and the length of time which it remains within the tank need be only long enough to allow a complete precipitation of the insoluble matters, and the accumulation, to some extent, of the fats upon the surface of the sewage. These matters can remain in the tank for an indefinite time; and, being acted upon by the bacteria of decomposition and putrefaction, will be slowly changed to the soluble form, and pass away to a large extent, perhaps, in the effluent of the tank. Thus, the sludge, the difficult factor in sewage purification, may perhaps be disposed of, and the sewage, staying a shorter time within the tank, will not have such an offensive odor, and will not make the disposal area so great a nuisance. The process has not been on trial long enough as yet, however, to determine accurately what percentage of the total volume of sludge can be gotten rid of in this way.

A COMPARISON OF BRITISH AND AMERICAN NAVAL VESSELS.

The following comparison by an English naval expert of the vessels, guns and armor in the British and United States navies, we find in the New York "Tribune," credited to the London "Mail." It appears to be a very fair and unprejudiced statement, and is, so far as we are aware, in accordance with the actual facts. The British navy is certainly in advance of all others in the world in its use of the wire-wound gun, which, by permitting higher pressures, larger powder charges and longer barrels, sends its projectiles home with a force which ordinary built-up guns of the same caliber cannot equal. The critic's remarks respecting the speed of battleships are also noteworthy:

American guns are not, I take it, so good as ours. The 60-ton weapon is a fine and powerful gun and has stood the strain of prolonged firing, but it is not better than the British 67-ton gun and is inferior, both in rapidity of fire and penetration through armor, to our 46-ton wire weapon. There can be little doubt that our 6-in. and 4.7-in. weapons of the quick-fire type are ahead of anything now manufactured in the United States. The British-built "New Orleans" is pronounced by American naval officers in the West Indies the best cruiser of her size in the United States Navy. Her guns have excited particular admiration, owing to their simplicity, accuracy and rapidity of fire.

When we turn from guns to projectiles and armor we are upon less certain ground. Two years ago the American Carpenter and Wheeler-Sterling shells were better than anything made in England. It is possible that to-day they are ahead of our projectiles, though with the very great attention given to this point by British manufacturers recently, it is not altogether likely. Our Hadfield projectiles are, I believe, among the very best. Still, the American Navy is probably at this present minute supplied with better armor-piercing projectiles than the British Navy, for the reason that the United States did undoubtedly get ahead of us.

In the matter of armor-plates England fell behind because, for some reason or other, the Admiralty in our earlier Harveyized plates did not use nickel. The Americans adopted a nickel steel, which has performed wonderfully in trials. But here again, I am glad to say, we have advanced greatly. The Krupp gas-hardening process, which has been adopted by our three great armor-making firms, when applied to nickel-steel plates, such as we now use, gives splendid results. The firm of Vickers has particularly distinguished itself for the armor which it has turned out in the last few months. Nor are Brown and Cammell behind their enterprising rivals.

The point in which American ships excel ours is in battery. It is well known that, ton for ton, the United States warship is beaten in armament only by the new ships now constructing for Germany, a young and audacious Power. Taking two new ships, British and American, these are the armaments:

"Canopus" (British).	"Alabama" (American).
Four 12-in.	Four 13-in.
Twelve 6-in.	Fourteen 6-in.
Ten 12-pdrs.	Seventeen 6-pdrs.
Six 3-pdrs.	Six 1-pdr.
Eight Maxims.	Four Maxims.
Four torpedo tubes.	Four torpedo tubes.

The American ship has a much heavier battery. Though, as has been said above, the British 12-in. gun shoots harder than the American 13-in., the projectile of the American gun is 400 lbs. heavier than that of our gun. Probably with crews of equal efficiency the American ship would win on guns alone, if her weapons were of the most recent type. She has two more 6-in. quick-firers, and the 6-in. gun is a very formidable and useful weapon.

In the matter of ammunition the British ship is better supplied for her heavy guns. She is no better supplied with 6-in. shells. And it must be remembered that she is 1,400 tons larger.

In armor the difference is most striking. These are the facts, set forth side by side to afford a contrast:

British.	American.
Side—Belt, 250 ft. by 18 ft. and 6 ins. thick.	Belt, 220 ft. by 7½ ft., from 16½ to 9½ ins. thick. Above this a belt 140 ft. long by 8 ft. broad, 5½ ins. thick. Above this another tier of armor, 140 ft. long by 7 ft. 6 ins. broad, 5½ ins. thick.
Heavy guns — Barbettes, 10-in.; shields, 6-in., sloped.	Barbettes and turrets, 15 to 17 ins.
6-in. guns — 6-in. casemates.	5½ ins.
Protective deck—Two, one 1-in., the other 2½-in.	One, 2¾ to 4 ins.
Armor on ram — 2 ins., a broad belt, covering the ship forward.	4 ins., a narrow belt.

It will be seen that the American ship is, beyond question, better protected than the British vessel. In the American the armor virtually sheathes the whole vessel amidships. In the British ship the armor is only a patch

—though a large patch. Moreover, there is no thick armor on the water-line, as we find in the American.

In speed and coal supply the British "Canopus" has a great advantage. Our ship is nominally good for 18¾ knots, and carries 1,900 tons of coal. The American is 2½ knots slower, and carries 1,200 tons of coal. In practice the difference of speed should be about two knots. Great importance is attached in this country to speed, and very rightly. We must always force the fighting if war comes, and our ships must be able to catch their enemies. They are none too fast, as matters stand, for France has smaller-battle ships than the "Canopus," now nearly ready for sea, with engines as powerful as hers.

It would be wise from our point of view to class the "Canopuses" as armored cruisers of the finest type. Then, perhaps, we should hear less of the superiority, in actual fighting points, of such ships as the "Alabama."

Turning to our cruisers, it does appear that the Americans are ahead of us. The "Brooklyn," for example, is much more heavily armed than the "Powerful" of about her own date; is very nearly as fast, and in coal endurance is equal to the British. Our smaller cruisers are enormously below the Americans of their own size in armament. I have always held with our American friend that in war the object should be to kill your enemy as quickly as possible, before he kills you. The more guns you can carry the more likely you are to hit the enemy and to kill his men.

It is said: "Oh, but we carry so much more amunition." No doubt we do, but the question is this, Would it not be wiser to copy other Powers, and translate this ammunition into guns? I notice that the newest Russian cruisers, of the size of our "Hermes," carry one more 6-in. gun, and have 180 rounds of ammunition per gun, against our ship's 200. Yet the Russian ship will steam 23 knots, natural draught, and ours only 20½.

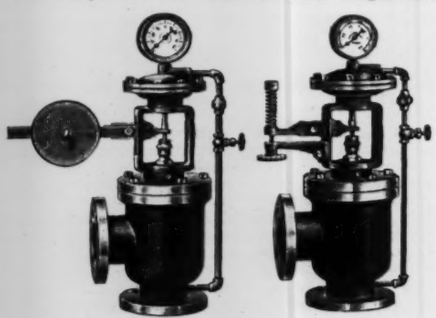
Take the "Olympia" as another example. She is just about the size of our "Eclipse." But she is 1½ knots faster; carries 300 tons more coal; has 4-in. armor on her big guns; a deck much thicker than the "Eclipse's," and a battery out of all proportion more powerful. Here are the figures:

"Eclipse."	"Olympia."
Five 6-in. quick-firers.	Four 8-in.
Six 4.7 in. quick-firers.	Ten 5-in. quick-firers.
Eight 12-pdrs.	Fourteen 6-pdrs.
Eleven small.	Ten small.
Three torpedo tubes.	Six torpedo tubes.

Summing up, then, we may pronounce our battleships in important respects better than the American, our guns much better, our projectiles as good, our armor as good, and our cruisers much worse.

NEW STYLES OF REDUCING VALVE.

The accompanying cuts show two styles of reducing valves recently put on the market by the Fisher Governor Co., of Marshalltown, Iowa, who are also manufacturers of the well-known Fisher steam pump governor. A standard gage is furnished with each valve, so that the low pressure can always be seen. The one with weight and



New Styles of Reducing Valves.
Manufactured by the Fisher Governor Co., Marshalltown, Iowa.

lever is especially adapted for extremely low pressures, and it will hold the lower pressure uniform even when the boiler pressure increases, or a greater part of the radiation is cut off. The style with spring attachment is more especially adapted for steamboat work. The valve and seats of these reducing valves are made of phosphor bronze.

ELECTRIC WELDING OF STREET RAILWAY RAILS.

In June, 1893, the Johnson Company, of Johnstown, Pa., which had been for nearly a year previously experimenting with the electric welding of rails, began welding the rails of the West End Street Railway of Boston, Mass. The apparent success then attained encouraged other roads to try the new method, and in a short time about 50 miles of track had been welded by this method in Boston, Cleveland, Johnstown, Brooklyn, St. Louis, and Detroit.

The approach of winter and with it cold weather caused the rail to contract and resulted in the breaking of many of the joints, usually just to one side of the weld showing that the breaks were the result of a weakening of the steel consequent upon the intense heat produced by the electric current. The experiments conducted at that time determined quite conclusively that a strength of 100,000 lbs. for a 6-in. rail, or thereabouts, was ample to resist the tension resulting from the annual change of temperature. 200,000 lbs. was therefore assumed as a necessary joint strength. A series of tests made on short sections demonstrated that welded joints could be made capable of standing considerably more than this figure. As a result of the failure of electric welding in Boston and elsewhere, the Johnson Co. refrained from a general introduction of its system and began a series of careful experiments to see if it were possible to produce the weld with its desirable features and still not destroy the structure of the adjacent steel. The solution was found to be very simple, and consists in putting the material at the weld under great pressure just after the weld is made and the current cut off and holding this pressure while the steel cools. In this way, the steel is prevented from crystalizing and losing its elasticity at the point next the weld. The company, after further experiments to thoroughly test this discovery, is again in the market.

FIG. 1.—THE ELECTRIC RAIL WELDING EQUIPMENT OF THE JOHNSON CO., JOHNSTOWN, PA., NOW OPERATING IN BROOKLYN, N. Y.

At present one of its equipments is in Brooklyn, engaged in welding about 45,000 ft. of double track on the Nassau Electric R. R. The welding equipment is composed of four cars, as shown in Fig. 1, containing the various electrical machinery instruments, sand blast, water tanks, regulators, etc. This train is transported about the country on flat cars, which land it as near the point where work is to be done as possible. The cars are then run onto the street railway lines and as each car is equipped with its own trolley and motors they are propelled by their own power to the desired position.

The car to the left in Fig. 1, contains a booster built by the Crocker-Wheeler Electric Co., of Ampere, N. J. This car complete weighs 28,000 lbs. The booster is a 125-HP. 500-volt, 200-ampere direct current electric motor directly connected to a 70-K-W. dynamo wound for 420 amperes at 175 volts at a speed of 750 revolutions per minute. Current for operating the booster motor is taken from the trolley wire by an ordinary trolley pole on top of the car and the altered current is carried through flexible cables to the next car where the rotary converter is placed.

In the converter car are the instruments for indicating line and booster voltage and currents in the various circuits as well as resistances for regulating the output. The rotary converter is a 4-pole machine, built by the Thomson Electric Welding Co., of Lynn, Mass. This machine has one armature provided with a commutator on one end and collector rings at the other. It runs 500 revolutions per minute, taking current on the direct current side from the booster circuit and converting it into alternating current at 300 volts. The alternating current is taken from two collecting rings and passes by flexible cables to the next car, in which is found the main switch, the relative coil for current regulation, the massive welding transformer and clamp and the mechanism for moving this. Here also are the pumps, tanks, etc., necessary for cooling the jaws of the clamp.

The welder is nothing more nor less than a large transformer, mounted upon a bail which swings from a heavy arm or crane arranged to be raised or lowered or swung from side to side by means of screws driven by a small electric motor taking current from the trolley. The transformer core is laminated soft iron wound with two primary coils for 300 volts alternating current and about 260 amperes, and insulated with oil. The secondary consists of one turn, which is only completed when welding, furnishes from 30,000 to 50,000 amperes at from 2 to 4 volts. This secondary is made up of the two casings or cast metal jackets, which surround the primary coils. The contact blocks forming the jaws of the welder are

Fig. 2.—The Thomson Electric Rail-Welder.
Thomson Electric Welding Co., Lynn, Mass., Makers.

hollow and are connected with a small pump which keeps water circulating through the blocks close to the weld and thus prevents their over-heating. To obviate carrying a large quantity of water it is cooled by a form of air cooler placed on top of the car, seen in Fig. 1. This is a shallow round galvanized iron tank provided with two bottoms, between which is arranged a spiral strip forming a winding passage at the center of which air is admitted from a small rotary blower. The upper bottom is full of fine holes, and the water above this is prevented from leaking through by the air which forces its way up through the holes, producing a cooling of about 10 or 20° F., as it passes out through the water.

The amount of current applied at the weld is regulated in two ways; directly, by adjusting the pressure of the jaws; indirectly, by varying the field resistance of the booster. A reactive coil is also placed in series with the primary of the welding transformer. This, however, is only used to prevent excessive sparking at the switch terminals when the circuit is broken. It consists of a simple solenoid in which is suspended a core composed of a bundle of soft iron wire.

The manner of applying the clamping to the rails is quite clearly shown in Fig. 2, in which it will be noticed that two heavy steel levers are pivoted beyond their centers and are connected at their upper ends by a double-acting hydraulic jack. A small hand pump, mounted upon one of the levers, suffices to produce any desired pressure in the jack which is referred through the levers to the joint.

Farther forward, in Fig. 1, and always in advance of the welding train just described, is the sand blast car containing a sand blast outfit, made by B. C. and R. A. Tilghmann, 126 S. 11th St., Philadelphia, Pa., an emery wheel, electric heaters to dry the sand, an electric motor and a belted air compressor. This car is cut away at the rear and is provided with canvas curtains which permit the joints to be cleaned previous to welding without scattering the sand and annoying passers by. The operator wears a helmet and cape, covering his head and shoulders.

In operation, the cars are run out at night, so as to interfere as little as possible with the schedule, and the sand blast is put to work clearing the rail joints already exposed by removing the paving for a space of about 2 × 2 ft. Shims of sawed rail sections are next wedged into place between the ends of the rails. The welding train is then moved forward until the welder hangs over the center of the joint. Two steel splice bars, 1 × 3 ins. by about 19 ins. (Fig. 4), are next clamped into place, so that the central strip (a) of each bar covers the junction of the rails. The pressure on the jaws is run up to 7-10 ton, or about 1,400 lbs., by the hand pump, current is turned on and the metal is watched until it welds. The current is broken and the pressure is increased to about 35 tons, under which the joint is kept until it is cooled. The jaws are then loosened and the car moved back just enough to put the jaws over the portion (b) at one end. This kite-shaped raised portion is produced by stamping the bars at the factory, so that a depression is formed on one side and the projection on the other. Into the depression on the back is fitted a flat steel stamping. Its purpose is to ensure an even bearing of the clamp blocks. The second weld is next made and cooled under pressure as before, and then the weld on the opposite end of the splice bar. At the end of about 15 minutes (during which current was on for about 6 minutes) the rail joint is complete and ready for use.

The amount of excavation required at the joint is small, considerably less than with the various forms of so-called cast welds. It is claimed that joints made by the welding process meet all the requirements of strength, give a certain amount of flexibility, an amount about equal to that of the rail itself, and afford an electrical bond far superior to any other form of joint.

Regarding the cost, an approximate idea can be obtained by figuring backward. There are three welds, per joint, current being on about 2 minutes per weld, a total of 6 minutes, during which close to 100 K-W. will be necessary to operate the welder and various auxiliary apparatus. This is 1-10 of 100 K-W. hours, or 10 K-W. hours per joint. The dollars and cents of this will depend upon the particular road where the welding is in progress, being more or less according to local circumstances and the efficiency of the plant. In any case, five or six men are necessary to operate the train as described and this force will average about 18 or 20 joints in 7 hours or between 2½ and 3 joints per working hour. With 30-ft. rails double track there would be about 700 joints per mile, which would mean 233 hours or about 24 days of 10 hours each per mile. To this must be added about 30 cts. per joint for cost of splice bars and other pieces used. Such a joint made in the usual way with fish plates and bolts would cost about $1.80 for material, exclusive of copper bonds and all labor. Cast joints, that is, those in which from 50 to 120 lbs. of cast iron is poured about the rail ends, vary in cost from $2.00 to $3.00 per joint.

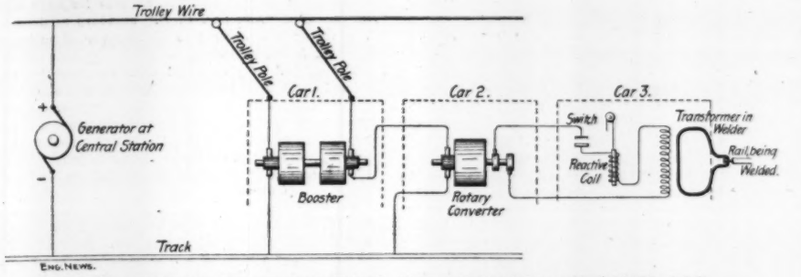


FIG. 3.—DIAGRAM OF CONNECTIONS AND APPARATUS EMPLOYED FOR ELECTRIC RAIL-WELDING.

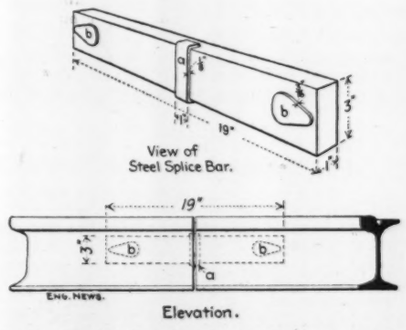


Fig. 4.—Steel Splice Bar Used, Showing Welding Points and Position of Splice with Reference to the Rails.

THE SMOKE NUISANCE in the railway tunnel in St. Louis is creating some agitation in that city, and efforts are being made, by the newspapers and by business men's organizations, to have an ordinance passed to secure its abatement. The "Star" is carrying on a "crusade" in favor of the ordinance, which is to compel the Terminal Railroad Association "to rid the tunnel of its blackness, foulness and disease-breeding germs by methods of illumination and ventilation." That the St. Louis tunnel is black and its atmosphere so thick with smoke as to be unbreathable every traveler who has passed through it knows, but that it contains any germs, disease breeding or other, is doubtful. Sulphur fumigation is an effective method of killing germs, and the tunnel is well fumigated every time a train passes through it.

THE HUDSON RIVER TUNNEL bondholders, through their trustees, the Farmers' Loan & Trust Co., of New York, and Mr. J. H. B. Kendall, of London, England, have made application to the New Jersey Court of Chancery for an order to sell the property in view of foreclosure proceedings on the mortgage of $4,000,000. It is expected that the order will be granted, when, it is stated, it is the intention of the bondholders to reorganize the enterprise and complete the tunnel. The status of the tunnel work was given quite fully in our issue of Nov. 25, 1897.

ANOTHER LONDON UNDERGROUND RAILWAY is under consideration, and as the company, known as the Great Northern & City Ry. Co., is capitalized at $8,000,000 and includes a number of prominent railway men, it is quite likely the road will be constructed. The plan is to excavate two 16-ft. tunnels three miles long, connecting the Finsbury Park Station of the Great Northern Ry. and Moorgate St. in the city proper. The regular steam suburban trains will be hauled through the tunnel by electric locomotives, making the trip in 12 minutes.

A ROYAL COMMISSION ON SEWAGE TREATMENT and disposal was recently appointed in England and is now holding meetings. The London "Surveyor" deprecates the fact that the press is excluded from the sittings.

TELEPHONE SUBSCRIBERS IN RUSSIA NUMBER 21,590, of which 11,171 are supplied by the Bell Company, the remainder by the government. The company has 15 exchanges in 11 districts, including St. Petersburg, Moscow, Warsaw, Odessa, etc. The government has 80 exchanges in 67 districts, requiring 2,875 miles of lines and 15,130 miles of conductors against 848 miles of company lines and 15,580 miles of conductors. The charges are: 5.7d (12 cts.) for three minutes; 11.4d. (23 cts.) for the use of trunk lines up to 33 miles and 1s. 7d. (48 cts.) for distances of about 65 miles.

AN ACETYLENE GAS PLANT has been installed in New Milford, Conn., for public lighting purposes. The holder has a capacity of 300 cu. ft. There are four generators, each holding 150 lbs. of carbide. The connections are such that water is permitted to gradually flow into one generator until the carbide is consumed, when it is automatically switched to the next generator, and thus the pressure and supply are maintained.

THE "GOLD FROM SEA WATER" ENTERPRISE of the Electrolytic Marine Salts Co., of North Lubec, Me., has suspended operations and the "inventor" of the process and manager of the company, "Rev." P. F. Jernegan, has absconded after having received $338,000 of the "profits," which were derived not from sea-water but from the stockholders. He sailed for Europe under an assumed name after having converted about $100,000 cash into government bonds in New York city, and his arrival at Havre on his way to Paris has been reported by cable. Steps have been taken to have him shadowed by detectives in France until papers can be sent charging him with embezzlement, on which his extradition may be secured. It is said that about $300,000 out of the $10,000,000 capital stock of the company was subscribed for in Newburyport, Mass., by bank directors and leading business men, who were led to subscribe through their confidence in the judgment of Mr. A. P. Sawyer, a local capitalist, and Mr. W. R. Usher, a large shoe manufacturer of that city, both of whom were directors in the company. One report says that $2,400,000 of the stock has been sold at par, that 45% of the money received went to the promoters, 20% to the "financial agents," and the remaining 35% into working capital, some of which was expended in the construction of the works at North Lubec, upon which 600 men have been engaged. The New York "Herald" of July 31 gives an interesting account of the preliminary experiments of the "inventor," near Providence, R. I., by which he obtained his first contributions of capital. It appears that a small shed was built at the extremity of a long slender wharf projecting from the shore of Narragansett Bay, and through a hole in the floor there was lowered by means of a windlass a large box containing a pan of mercury. An electric battery supplied by the "inventor" was applied during a whole night in the presence of some capitalists from Middletown, Conn., who had brought with them the mercury. The next morning the mercury was lifted from the water and given to a chemist who assayed it, and found in it $4.50 of gold, and there-

upon the capitalists, much pleased, paid the first installment on their investment. The deception in the experiment, according to the detective, consisted in a diver's proceeding under water during the night to the box, pouring out the mercury, and substituting for it another lot of mercury containing gold. Upon this basis was floated the $10,000,000 company. Its success in obtaining gold at North Lubec was attested by its sending frequently to the New York Assay office "gold bricks" containing each about $2,000 of gold, and the exhibition of similar bricks at the company's office in Boston. The "gold from sea-water" scheme thus appears to have been one of the most gigantic swindles of recent years. It was similar in many respects to the Electric Sugar Refining swindle in New York city in 1884, by which many prominent business men, including even sugar refiners, were victimized. One of the operators in that scheme was convicted and sentenced to nine and a-half years' imprisonment. It is to be hoped that a like fate will meet the Rev. Jernegan and his accomplices.

ANNUAL CONVENTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The thirtieth annual convention was held at Detroit, Mich., July 26 to 29, the headquarters being at the house of the Fellowcraft Club, the use of which was kindly tendered by its Board of Governors. A special train was run from New York, over the Lehigh Valley and Wabash railways, and special accommodations were provided by the Wabash R. R. for members from Chicago and St. Louis. There was a large attendance, both of members and guests.

The opening session was called to order about 10 a. m., July 26, Mr. A. Fteley, President of the Society, being in the chair. In consequence of the absence of the Mayor, Rev. Dr. Arnold, of Detroit, delivered the address of welcome, which was responded to by Mr. Fteley. The President's annual address was then read by the Secretary, an abstract of which we gave last week.

After the reading of the address, chairmen of the district committees to select members of the nominating committee were appointed by the chair. It was then suggested that the discussion of the proposed amendments to the constitution should be taken up, but on motion of Mr. Geo. S. Morison it was voted to defer this until the time set for it upon the program. The meeting then adjourned.

The afternoon session was devoted to a discussion of the paper by Messrs. Charles D. Marx, Charles B. Wing and Leander M. Hopkins, on "Experiments on the Flow of Water in the 6-Foot Steel and Wood Pipe Line of the Pioneer Electric Co., at Ogden, Utah." Mr. Henry Goldmark gave a brief synopsis of the general points of the paper, after which some written discussions were read by the Secretary, in which doubts were expressed as to the accuracy of the results of the experiments, in view of the conditions under which they were made. Mr. Kuichling also expressed somewhat similar views. Mr. John C. Trautwine, Jr., who was a member of the committee of the Franklin Institute, appointed to report upon the Venturi meter, thought the investigations made by these authors as to this meter are particularly valuable, especially as there is some doubt as to whether the piezometer measurements should be made at the top of the pipe or at the middle of the pipe. Experiments made at Philadelphia showed that the loss of head is less with this meter than with any other, but the loss increases as the square of the velocity. A 20-in. Venturi meter was placed on a certain supply main, and when several fire engines were pumping from this main to extinguish a fire they could not get enough water until the meter was cut out and the water sent through the by-pass.

At 3:30 p. m. the meeting adjourned, and the party boarded a number of electric cars provided by the Detroit Electric Ry. Co. for a ride about the city. The cars first went out on Woodward Ave., which is a handsome residence thoroughfare, and then along Jefferson Ave. to the water-works pumping station, where a short time was spent in examining the plant and in getting a photograph of the party. During this trip the width of the streets, their cleanliness, and the excellence of the pavement (mainly asphalt and brick) attracted considerable attention, especially from those interested in municipal work.

In the evening there was a steamer excursion on the Detroit River and St. Clair Lake, by courtesy of the Detroit, Belle Isle & Windsor Ferry Co. A band was provided, and dancing was indulged in on the upper deck.

The morning session on July 27 was called to order about 10:15 a. m. The first paper taken up was on "The Determination of the Safe Working Stress for Railway Bridges of Iron and Steel," by Mr. G. Herbert Stone. There was no discussion, nor were the written discussions presented, the President considering that the subject was too mathematical to be considered in the limited time that could be devoted to it. The Secretary then read a synopsis of Mr. Charles H. Snow's paper on "Marine Wood-Borers," an abstract of which was given in our issue of July 21. In the discussion it was stated that at San Francisco the teredo now attacks timbers which were formerly almost free from their attacks. Creosoting was considered one of the best protective methods, as it prevents decay as well as the attacks of borers, etc., but it is not universally reliable, as the oil will penetrate the softer rather than the harder parts of the wood, leaving the latter liable to attack. Mr. Harrod referred to the use of sewer tile slipped over the piles, the annular space being filled with sand, while Mr. Robert Moore described a process consisting of wrapping the pile with cloth treated with a certain mineral cement. One member thought that metal piles will be the most practicable solution of the question, especially in view of the low cost of iron and steel. The discussion began to drift towards methods of protecting piles, but the President ruled that this was not in order, and limited the discussion to the subject of the borers themselves. Mr. Wegmann said that while the limnoria is found in Boston harbor, the teredo is only rarely found, and is killed off by the severe winter cold. Cape Cod appears to be about as far north as the latter will reach.

The long and detailed paper by Mr. J. A. Ockerson on "Dredges and Dredging on the Mississippi River" was next taken up, the discussion being opened by Mr. Harrod. Work on the channels, he said, must be commenced as soon as the river has fallen to about mid-stage, and will allow of the surveys being made. The use of dikes and training works would necessitate extensive preparations at a multitude of places, as well as large gangs of men and extensive plant to put in these works. One of the new dredges will be self-propelling, thus avoiding the trouble and expense of a tender. It is desirable to keep the delivery pipes as short as possible, as a pipe 1,000 ft. long will deliver 25 or 30% less than a pipe 500 ft. long. As the dredged channels are usually diagonal to the current he advocated depositing the dredged material on the downstream side of the cut or channel.

Prof. L. M. Haupt referred to the use of portable jetties or dams, which are used mainly on the crest of bars, and consist of steel panels, with mats, secured to piling. Jetties or training walls to increase the scour through channel could be made in the way suggested by Mr. Harrod. The portable dams have been used with success in water 10 ft. deep and over. They cost about $3 per lin. ft., and 250 ft. can be built in a day. Another member thought the paper should have given credit to Mr. A. B. Bowers for the development of the hydraulic dredging system, and still another considered that the tables of the results of tests were unsatisfactory, the tests of different dredges having been made under such different conditions that the results could not properly be compared.

The next paper was on "The Reservoir System of the Great Lakes of the St. Lawrence Basin; Its Relation to the Problem of Improving the Navigation of These Bodies of Water and Their Connecting Channels," by Capt. Hiram M. Chittenden, U. S. Engineer Corps. An abstract of this was read by Mr. James A. Seddon, the author of an appendix to the paper, giving "A Mathematical Analysis of the Influence of Reservoirs Upon Stream Flow." The author of the paper thought that it would be best not to attempt to modify the oscillations in the lake levels, and that if such modification should be attempted it could best be done by some form of movable dam rather than by a fixed submerged weir, at the outlet of Lake Erie.

The discussion brought out considerable opposition to the statements and suggestions of the paper, and Prof. J. B. Johnson considered that the acceptance of its conclusions would mean stopping all further improvement. Mr. Rafter thought the position taken in regard to the question of rainfall in the Great Lakes was incorrect, and presented a somewhat lengthy discussion on this point. Mr. George Y. Wisner and Mr. Lewis M. Haupt also took part in the discussion and presented views adverse to those of the author.

At the afternoon session, the district committees presented nominations for members of the committee to nominate officers for 1899, and the nominations were confirmed as follows:

District No. 1.—Henry G. Prout, New York city.
District No. 2.—J. W. Ellis, Woonsocket, R. I.
District No. 3.—Emil Kuichling, Rochester, N. Y.
District No. 4.—Lewis M. Haupt, Philadelphia, Pa.
District No. 5.—Prof. Ira O. Baker, Champaign, Ill.
District No. 6.—N. W. Eayrs, St. Louis, Mo.
District No. 7.—Andrew Rosewater, Omaha, Neb.

The next subject was the selection of the place for the next annual meeting, and the membership at large seemed to have taken even less interest than usual in the matter, the letter ballot having resulted in only 56 votes. Washington and Atlantic City received the highest number of votes, the number being five in each case. Then followed the usual amusing and mildly acrimonious discussion on the subject. Mr. George S. Morison suggested that the convention be held at some point in the extreme South in April, 1899, but after a good deal of desultory talk this motion was defeated by a vote of 68 to 28, the larger vote being in favor of leaving the matter to the Board of Direction without any suggestion from the meeting. Possibly the discomfort due to the heat which prevailed in the convention hall had some influence in this, the very idea of going South suggesting more heat. Prof. Fuertes favored Ithaca and Cornell University, and a motion by Mr. B. M. Harrod was carried, to the effect that the convention should be held at some place where the entire party can be accommodated in one hotel.

An amendment to the constitution was also carried, and without discussion. This amendment does away with the office of Auditor, and puts the work of that office upon the Secretary and the Finance Committee, thus saving the Society the sum of $1,000 per year.

The question of submitting the appointment of committees on "rail joints" and "paints and painting" to a letter ballot was then taken up, but the discussion turned largely on the powers of the meeting and the Board of Direction as to modifying the terms of the original resolutions adopted calling for the appointment of such committees. Apart from this, Mr. Don J. Whittemore deprecated the work of committees, on the ground that the Society ought not to undertake work of this kind, which, he believed, should be done by individuals for themselves. Mr. Berg and Mr. Seaman, however, expressed the opinion that investigations by committees are among the important purposes of the Society and that a committee can get information and do work which no individual can or will do. Mr. Morison did not approve taking up the entire broad subject of rail joints, but thought a committee ought to be appointed to prepare standard sections for angle bars to fit the so-called "Am. Soc. C. E." standard sections of rails. The vote was 9 against to 46 in favor of submitting the question to letter ballot.

The subject of paints and painting, however, was considered to be of a somewhat different character, the great objection appearing to be that the inquiry would inevitably run foul of patents and manufacturers, and it was eventually decided that this proposed investigation should be dropped, and not submitted to letter ballot.

This concluded the business proceedings and the meeting then adjourned.

On Thursday, July 29, a large party left the Brush St. Station at 9.15 a. m., on a special train for Port Huron, provided by the Grand Trunk Ry. At Port Huron the party boarded a train of new gondola cars fitted with seats, which train was then run through the St. Clair tunnel to the Canadian side, and then back again. The train was pushed through in each direction, so as to have no trouble or discomfort from the smoke and gases from the engine. It is interesting to note that the huge tunnel engines, having ten driving wheels, are no longer fitted with side tanks, but have large tenders, as is the practice with ordinary road engines.

The Grand Trunk Ry. train then carried the party to the St. Clair River, where the steamer "Pleasure" was in waiting, and lunch was served as soon as the party was on board. The steamer started about 12.30 p. m., and after a very delightful trip down the St. Clair River and lake and the Detroit River, reached Detroit about 5 p. m.

The final session was called to order about 10 a. m., July 29, when the paper by Mr. D. A. Molitor on "Three-Hinged Masonry Arches, with Special Reference to Long Spans," was taken up. Mr. Goldmark, who opened the discussion, referred to the theoretical advantages of the three-hinged arch, but considered that it would have greater deflection than a solid masonry arch, and that therefore it would be inferior to the latter for railway bridges. Furthermore, as the arch masonry is but a small percentage of the total masonry in the structure, the slight saving in material by the use of a three-hinged arch is of but little importance. M. W. G. Berg took a similar view, and thought that the advantages of this type of arch would probably be more balanced by the increased difficulty and labor of design and construction.

Prof. J. B. Johnson, however, thought that a distinction should be drawn between difficult and uncertain computations, and thought while those for a three-hinged arch may be difficult those for a solid arch are very uncertain in results. If the principle is correct, the cost of making the necessary computations will be as nothing compared with the saving in cost of the structure.

After this, a series of resolutions of thanks to local authorities, transportation companies, etc., was adopted, and the convention then adjourned.

In the afternoon a party went down to Wyandotte on a parlor car of the electric railway to visit the shipbuilding yard of the Detroit Dry Dock Co., where the iron freight steamer "Troy," for the New York Central R. R., is now being completed.

In the evening a reception was held at the Detroit Club, and was a very sociable and enjoyable occasion.

The meeting was eminently successful, the only drawback being that the party was distributed among several hotels, so that there was less opportunity for general sociability and the making of acquaintances than when the entire party is accommodated under one roof. This led to the adoption of a resolution, as already noted, to the effect that the next convention should be held at some place where all the members and their guests can be accommodated in one hotel. The attendance was exceptionally large, there having been about 230 members and 300 guests present. With the exception of one or two very hot days, the weather was exceedingly pleasant. The Society was most hospitably entertained, and all the excursions were enjoyable and were managed without a hitch. As to the business part of the proceedings, perhaps the less said the better; most of the papers were presented in a perfunctory way, considering their value and importance, and the discussions were in too many cases brief and unimportant. It is possible that at some future day the Society will boldly omit technical papers and discussions entirely from its summer meetings.